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RESEARCH TRIANGLE INSTITUTE
Durham, North Carolina

FINAL REPORT

R-CU-154

# Cost and Protection Analysis of NFSS Structures

Edward L. Hill and Carolyn M. Parker

22 January 1965

Prepared for
Office of Civil Defense
Department of Army - OSA
Under
Contract No. OCD-PS-64-56
Subtask 1115B

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ABSTRACT

This constitutes the final report of the research on area factors and categorization of building structural characteristics which was completed under Contract No. OCD-PS-64-56 before management responsibilites were transferred to USNRDL.

A statistical study of National Fallout Shelter Survey Phase 2 building structural characteristics extracted from OCD files is reported. A total of 344 buildings of the original Phase 1 sample of 1541 (reported in E. Hill, et al. Analysis of Survey Data. Final Report R-OU-81. Durham, N. C.: Research Triangle Institute, 15 February 1964) was surveyed by Architects-Engineers in the NFSS Phase 2. Included in these buildings are 1030 basement shelter areas, 262 first story shelter areas, and 838 upper story shelter areas. The modal value for basement sill heights is 5 feet; whereas 80 percent of the sill heights for the first stories are from 2 to 3 feet, and for upper stories 90 percent are from 2 to 3 feet. Parallel partitions occur in 51 percent of the basement shelter areas, 68 percent of the first story shelter areas, and 78 percent of the upper story shelter areas. Cross partitions occur in 761 of the 2130 shelter areas.

"Area factors" are multipliers used to estimate the fraction of the total floor area offering protection greater than a predetermined value. A unique set of area factors which do not vary with structural details of the building are used in the NFSS. Several shortcomings of these approximate area factors are discussed: (1) cases in which center PF's are lower than off-center PF's; (2) the effect of interior partitions; (3) the effect of floor thickness; (4) the effect of apertures; and (5) shelters with predominantly roof contribution. Analyses of shelters with only roof contribution and of shelters with both ground and roof contribution are presented. Methods of determining more nearly correct area factors for each situation are given for use with simplified hand computational procedures. Lastly, for more exact computations, it is recommended that the shelter area be calculated by computing PF's at several off-center locations and determining graphically the areas which reach a prescribed PF.

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Chapter I

## Summary

### I. INTRODUCTION

The OCD description of Subtask 1115B, Cost and Protection Analysis of NFSS Structures, Contract No. OCD-PS-64-56, is as follows:

> "Analyze Phase 2 data from the NFSS to indicate relative importance of shielding characteristics in order to improve PF calculations and to indicate the most important modifications to improve PF Utilize this data and studies of recurring types of key facilities under various geographic and construction conditions to identify the most critical engineering characteristics of the structure which would require modification for occupancy and operation in a fallout situation. Provide PF computational procedures for special characteristics of those key facilities for the electronic computer program."

The Research Triangle Institute was informed on 12 May 1964 that the U. S. Naval Radiological Defense Laboratory (NRDL) was to have management responsibility for OCD Subtask 1115B. A new contract, N 228-(62479)-66109, was executed by NRDL for the completion of work begun under the original OCD contract.

This constitutes the final report of the research on area factors and building structural characteristics which was completed under Contract No. OCD-PS-64-56 before management responsibilities were transferred to NRDL. The data presented in this report will be combined with the remainder of the research under OCD Subtask 1115B in a more comprehensive Report R-OU-196 upon completion of the NRDL contract.

## II. FINDINGS

### A. Categorization

The results of a statistical study of NFSS (National Fallout Shelter Survey) Phase 2 building structural characteristics are contained in Chapter 2 and Appendix A. An analysis of building structural characteristics contained in Phase 1 data was previously reported in Reference 1 . Therefore, this study completes the evaluation of all building characteristics reported in the NFSS for an original sample of 1541 buildings. A total of 844 buildings of the original 1541 was surveyed by AE's in the NFSS Phase 2. Included in this report is an analysis of the occurrence of Phase 2 data on areaways, aperture sill heights, and interior partitions in both building parts and shelter areas. These data, classed by protection factor, are of interest in determining the correlation between structural data and protection from fallout radiation.

There were 1030 basement shelter areas, 262 first story shelter areas, and 838 upper story shelter areas, giving a total of 2130 shelter areas reported. A total of 493 areaways were reported in 337 building parts. Sill heights reported for basements had a mode of 5 feet, whereas 80 percent of the sill heights reported for first stories were from 2 to 3 feet and for upper stories 90 percent were from 2 to 3 feet. Parallel partitions were reported for 51 percent of the basement shelter areas, 68 percent of the first story shelter areas, and 78 percent of the upper story shelter areas. Cross partitions were reported for 761 of the 2130 shelter areas.

### B. Area Factors

Area factors represent fractions of total floor areas offering protection greater than a predetermined value. For the intended objective of determining gross estimates of the total number of available shelter spaces by machine methods, the area factor approach used in the NFSS Phase 1 Computer Program was excellent. However, it is recommended that a careful analysis of each building utilizing area factors should be made before final determination of the actual shelter area is made. Several shortcomings of area factors are discussed: cases in which center PF's are lower than off-center PF's; the effect of interior partitions, floors, and apertures; and shelters with predominantly roof contribution.

Analyses of shelters with all roof contribution and of shelters with both ground and roof contribution are presented. Methods of determining area factors for each situation are given. For more exact computations, it is recommended that actual shelter area be calculated by computing PF's at points in addition to the center and determining the distances from the center that reach a prescribed PF.

## Chapter 2

## A Statistical Analysis of the Influence of Phase 2 Building Characteristics on Fallout Radiation Shielding

### I. INTRODUCTION

Statistical data on building configurations were not available when the NFSS (National Fallout Shelter Survey) Computer Program (Reference 2) was developed to calculate protection factors. Therefore, assumptions had to be made in this program regarding the importance of various building characteristics. Categorization of building structural characteristics of NFSS buildings is of interest in determining the correlation between structural data and protection from fallout radiation afforded by shelter areas* and building parts.

Under OCD Subtask 1115A, Analysis of Survey Data, RTI "categorized the surveyed structures with respect to technical shielding characteristics. . ." For that subtask, RTI made a statistical study of building characteristics which were reported on NFSS Phase 1 FOSDICS (Film Optical Sensing Device for Input to Computers). The results of the study were reported in Chapter 3 of the final report for Subtask 1115A (Reference 1).

Certain structural shielding characteristics such as areaways, aperture sill heights, and interior partitions were not fully reported in the NFSS Phase 1 data. These characteristics were reported in Phase 2; however, summarized Phase 2 data were not available at a single location in time to be categorized in Subtask 1115A. Therefore, the purpose of this chapter is to complete the categorization of all technical shielding characteristics reported in NFSS data.

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* It is important to note that shelter areas are stories containing shelter in a building or building part. Thus, a "shelter area", as used in this chapter is not necessarily the entire extent of NFSS shelter in a single story of a building.

## II. SAMPLE CHARACTERISTICS

The sample of Phase 1 data which was categorized in Subtask 1115A contained 1541 buildings. However, there are only 844 buildings in the sample of Phase 2 data to be categorized. Phase 2 instructions state that all shelter areas surveyed in Phase 1 must be at least PF Category 2 or better for additional analysis in Phase 2. Therefore, 483 of the 1541 buildings in the Phase 1 sample were eliminated in the Phase 2 sample because they contained only PF Category 1 shelter areas. Also, Phase 2 data were not reported for 214 other buildings in the sample for one of the following reasons:

1. Permission to survey the building in Phase 2 was not given by the building owner.
2. The building had been destroyed since the Phase 1 survey.
3. In most cases no analysis or cost estimates were made for shielding improvements above the first story.

General characteristics of the Phase 1 and Phase 2 data used in categorization and characteristics of their parent population are listed in Table I.

TABLE I

Phase 1 and 2 Categorization Sample Characteristics

1. Total number of shelter areas on M2 file (Total NFSS Phase 1) = 1,042,027
2. Total number of buildings (Total NFSS Phase 1) = 308,130
3. Total number of buildings rejected (Buildings containing no shelter areas rated in PF Category 1 or higher were rejected) = 73,646
4. Total number of buildings in the Phase 1 sample = 1541
5. Total number of buildings in the Phase 2 sample = 844
6. Total number of building parts in the Phase 1 sample = 2091
7. Total number of building parts in the Phase 2 sample = 1167
8. Total number of shelter areas (PF Categories 1 through 8) in the Phase 1 sample = 4421
9. Total number of shelter areas (PF Categories 2 through 8) in the Phase 2 sample = 2031

## III. APPROACH TO STATISTICAL STUDY IN PHASE 1 CATEGORIZATION

The statistical study made in categorizing Phase 1 data was presented in Chapter 3 of the final report for Subtask 1115A. In that study, a random sample of 1541 buildings was selected from the NFSS Phase 1 M1 and M2 files (Reference 2), which are maintained at the National Bureau of Standards Computation Laboratory.

Statistical studies of detailed structural properties were made to determine the correlation between structural data and protection from fallout radiation. More specifically, the study involved preparation of statistical tabulations relating protection factors with the number of shelter areas (PF Category 1-8) and number of buildings falling within selected incremental ranges of certain structural characteristics. The specific structural characteristics studied for shelter areas were:

1. story number
2. percent apertures
3. interior partitions
4. floor area
5. wall mass thickness (psf)
6. contaminated plane width
7. dose source
8. percent basement exposure

The specific structural characteristics studied for buildings were:

1. story number
2. percent apertures
3. interior partitions
4. floor area
5. wall mass thickness (psf)
6. physical vulnerability (PV code)
7. number of building parts

All data processing and calculations were performed on the National Bureau of Standards IBM 7090 computer. A tabular presentation of this study is given in Appendix E of Reference 1.

It is expected that the tabulations of the above structural characteristics for the sample of 844 Phase 2 buildings would differ slightly from those for the sample of 1541 Phase 1 buildings. The tabulations for the 483 buildings in the Phase 1 sample that had only PF Category 1 shelter areas are readily identified; therefore, only the 214 buildings not included in the Phase 2 data for other reasons would modify the statistics. Because only slight modifications are expected, it is not deemed essential to re-categorize the Phase 1 data for the same 844 buildings that were evaluated in Phase 2. Doing this would also be complicated by the fact that shelter area PF's were often changed in Phase 2 and there is no merged record of Phase 2 PF data and Phase 1 structural data. Accordingly, it is recommended that where structural data are required for all NFSS Phase 2 buildings, they be based upon the analysis of Reference 2 after deletion of PF Category 1 shelter areas.

## IV. PHASE 2 CATEGORIZATION PROCEDURES

### A. Introduction

The source of Phase 2 data is the Phase 2 DCF's (Data Collection Forms)(Figure 1) on which structural data were entered for the buildings by AE (architect-engineer) contractors (Reference 3). These Phase 2 data were transferred to magnetic tape by the Bureau of the Census. In order that RTI could categorize Phase 2 data, the Bureau of the Census prepared a printout from their magnetic tapes of the Phase 2 data for the 844 buildings, 1167 building parts, and 2031 shelter areas (story of a building or building part) in the sample. Using this printout, RTI categorized the building parts and shelter areas with respect to areaways, aperture sill heights, and interior partitions. The data which were taken by hand from the printout are presented in Appendix A in tabular form, with a fractional table computed for each element of data categorized. All fractions are rounded to four significant figures.

### B. Basement Areaways

Information concerning basement areaways is given in columns 70 through 76 of the Phase 2 DCF. Data entered in these columns described the location, length, distance from corner, and width of basement areaways and the height of window openings in the basement walls exposed by the areaway. RTI categorized the data in columns 71, 74, and 75. Column 71 contains the length of the areaway, expressed to the nearest (estimated) 10 percent of the length of the side in which it was located. Columns 74 and 75 reported the width, to the nearest foot, of the areaway. Table A-1 of Appendix A shows the total number of building parts which had areaways reported. Tables are also presented for the total areaways in all PF categories (Table A-II) and for each PF category (Table A-III - A-IX). The areaway information was tabulated by width (from 2 to > 10 feet) and by percent of building side length (0 through 90 percent).

Figure 1
NFSS Phase 2 Data Collection Form

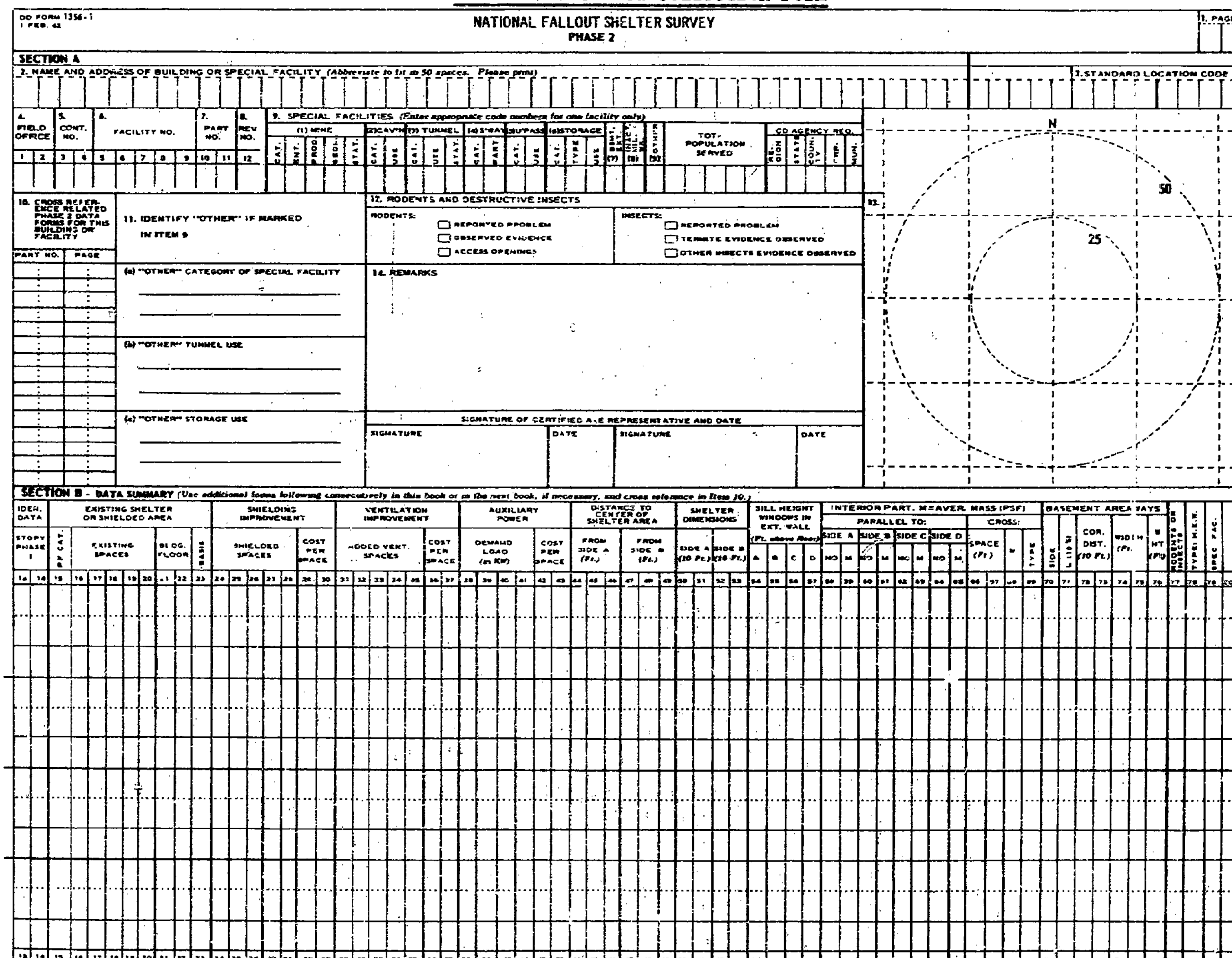


Figure 1 (Continued)

**SECTION C**

**Part 1 - SHELDING**

| | |
|---|---|
| Sketch portions of facility and/or shelter area analyzed. Indicate part number, story number, or basement/sub-basement. Show dimensions and identify features applicable to computation (use symbols, Table 5, EM). If multiple identical areas in a part, indicate number. Attach additional sketches, this size, if necessary. | Identify by number the chart(s) used in computation. List data, with values, required for chart solution (use symbols, Table 5, EM). State conclusions and key to sketch (psf to be added, type material, other necessary structural modifications). Estimate total cost for each shelter area. Also state basis for changes in PF or capacity recorded in Columns 15 through 20, Section B. |

**Part 2 - VENTILATION**

| | |
|---|---|
| Sketch facility and/or shelter area showing location of mechanical improvements required for habitability (use accepted industry symbols). | List data to support conclusions (existing CFM fresh air natural; mechanical). State conclusions (CFM fresh/recirculated air required). Estimate total cost (fan unit, dampers, filters, ductwork, louvers, grilles, registers, switches, wiring). |

**Part 3 - ELECTRICAL**

| | |
|---|---|
| Sketch facility and/or shelter area showing location of electrical requirements for power and lighting (use accepted industry symbols). If standby generator to serve community or complex of facilities, state location. | List data to support conclusions (demand load in kw for each electrical requirement). If standby generator required, describe characteristics (kw, dc/ac, phase, cycle, voltage, diesel/gasoline, fuel consumption at full load). Estimate total cost (generator cost prorated for each shelter area; distribution feeder with accessories, power and lighting circuits, circuit breakers, miscellaneous). |

C. Aperture Sill Heights

Aperture sill height data were entered by the AE's in columns 54 through 57 of the Phase 2 DCF. The predominant sill height, to the nearest foot, of the window openings (apertures) in exterior wall "A" through "D" above the appropriate floor level was entered in these columns by the AE's. If the wall under consideration had no apertures, an "x" was entered in the appropriate column.

Table A-X gives the total numbers of basement, first story, and upper story shelter areas in each PF category with sill heights reported. Data for sill heights reported in the basement, first, and upper stories are given in Tables A-XI through A-XIII. In these three tables, an average of the sill heights reported in the Phase 2 DCF columns 54 through 57 is tabulated by PF category. If an "x" appeared in columns 54, 55, 56, or 57, the column or columns were excluded from the average.

D. Interior Partitions

1. Parallel Partitions

The number and the average psf, estimated to the nearest 10 psf, of parallel partitions (those partitions such as corridor walls extending parallel to Sides A, B, C, and D) were recorded by the AE's in the Phase 2 DCF columns 58 through 65. The total numbers of basement, first story and upper story shelter areas with parallel partitions reported are presented in Table A-XIV by PF category. In order to categorize these parallel partition data by shelter areas, it was necessary to determine an average partition psf for each shelter area. Therefore, RTI multiplied the average psf reported for each of the four sides by the number of parallel partitions reported for that side, added these four products, and divided this total by four in order to get the average psf for each shelter area. These parallel partition data were categorized and are reported in Tables A-XV through A-XVII for basement, first, and upper stories by PF category and average psf per shelter area.

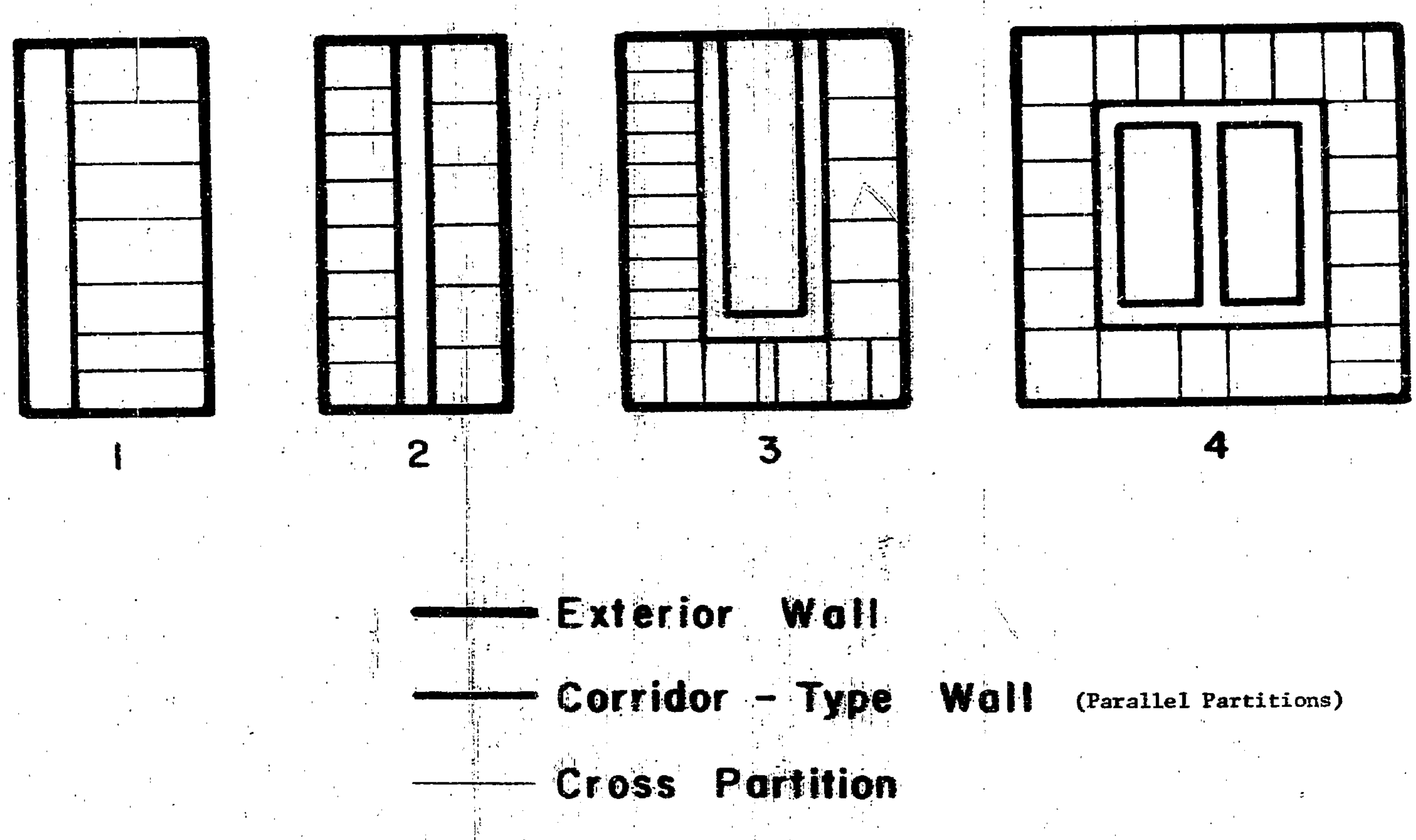
2. Cross Partitions

Cross partition (those partitions separating adjacent rooms and not recorded elsewhere) data are found in columns 66 through 69 of the Phase 2 DCF. The estimated average spacing in feet is found in columns 66 and 67. The average psf, estimated to the nearest 10 psf, is in column 68. The general pattern of the cross partition arrangement in the shelter area is indicated in column 69 using the code number for the type which corresponds to the one of the four general patterns presented in Figure 2 considered to best resemble the building part described. RTI categorized the data found in columns 68 and 69. The numbers of each type cross partition reported are shown in Table A-XVIII and a breakdown by shelter area and PF category is given in Table A-XIX. These data were categorized separately for each type of cross partition (Types 1-4) by PF category and average psf for basements, first, and upper stories and reported in Tables A-XX through A-XXII.

FIGURE 2

Code Number For Building Type

(Column 69 of Phase 2 DCF)



## V. DATA ANALYSIS

### A. Introduction

The Phase 2 data categorized in this report contained 844 buildings and 1167 building parts. In these building parts, there were 1030 basement shelter areas (story in a building or building part); 262 first story shelter areas, and 838 upper story shelter areas, giving a total of 2130 shelter areas reported. It is interesting to note that 1030 (88 percent) of the 1167 building parts in the Phase 2 sample have basement shelter areas which account for 48 percent of the total shelter areas. The Phase 1 data indicated that 81 percent of the building parts contained basement shelter areas (PF Category 1 through 8). The increased percentage of basement shelter areas in Phase 2 is expected because of the number of Phase 1 upper story shelter areas in PF Category 1 which were not further evaluated in Phase 2.

As stated previously, this report presents a categorization of areaways, aperture sill heights, and interior partitions contained in the Phase 2 data printout which RTI obtained from the Bureau of the Census. A few of the more interesting facts noted in categorizing these technical shielding characteristics are discussed below.

### B. Areaways

There were 493 areaways reported by the AE's for the 844 buildings categorized in this chapter. Of the 1167 building parts reported, 337 have one or more areaways. A total of 109 of these building parts had areaways reported on more than one building side. It is interesting to note that seven areaways were reported with their percent of building side length from 0 - 5 percent. The number of areaways reported are rather evenly dispersed for adjacent shelter areas in PF Category 2 through 8. These areaways are reported in Appendix A with widths ranging from 2 to > 10 feet; however, a definite trend toward narrow widths is shown by the fact that 437 of the 493 areaways reported have widths of from 2 to 6 feet. These data indicate the importance of including areaway contributions in basement PF computations.

C. Aperture Sill Heights

In basement shelter areas, the average aperture sill heights reported are rather evenly dispersed from 0 to 9 feet with a mode of 5 feet. However, 80 percent of the sill heights reported for first stories are from 2 to 4 feet and for upper story shelter areas 90 percent are from 2 to 3 feet high. For upper stories, there were no sill heights reported higher than 5 feet. Sill heights were reported for only 625 of the 1030 basement shelter areas categorized; however, it is more interesting to note that 56 of the 262 first story shelter areas and 19 of the 838 upper story shelter areas had no sill heights reported, thereby indicating no apertures for these 75 shelter areas. This would cause the shelter area to have higher PF's, but it also means that these areas would require additional ventilation to be eligible for marking at 10 square feet per shelter space.

D. Interior Partitions

1. Parallel Partitions

Parallel partitions are reported in Appendix A with average psf (pounds per square foot) per shelter area (see Section IV.D.1.) of from 5 to > 300 psf. Parallel partitions were reported for 525 of the 1030 basement shelter areas (51 percent), 178 of the 262 first story shelter areas (68 percent), and 656 of the 838 upper story shelter areas (78 percent). In the NFSS Phase 1 categorization sample, only 17 percent of all shelter areas had interior partitions reported. The numbers of parallel partitions reported in Phase 2 are rather evenly dispersed by average psf for basement, first, and upper shelter areas. They also have a median of 25 psf for basement shelter areas, 32.5 psf for first story shelter areas, and 25 psf for upper story shelter areas.

2. Cross Partitions

Cross partitions were reported for 761 of the 2130 shelter areas categorized. Of these cross partitions, there were 245 reported for basement shelter areas, 98 for first story shelter areas, and 418 for upper story shelter areas.

There were four types of cross partitions reported on the Phase 2 DCF's (see Figure 2). For basement shelter areas, 89 percent of the cross partitions reported are Type 1 or Type 2 partitions. In the first story shelter areas, 60 percent are Type 2 partitions. Finally, for upper story shelter areas, 72 percent are Type 2 or Type 4 partitions. Of the 761 shelter areas with cross partitions reported, 48 percent are Type 2. It should be noted that of the total cross partitions reported only 9 percent are Type 3 partitions.

The cross partitions are categorized by PF category and average psf (see Section IV.D.2.), as well as by type. For all PF Categories (2 through 8), the different types of cross partitions are rather evenly dispersed from 10 through 90 psf. The median psf for all types is 40 psf for basements, 30 psf for first stories, and 30 psf for upper stories. The modal psf for all types is 90 psf for basements, 30 psf for first stories, and 30 psf for upper stories.

## Chapter 3

## Area Factors

### I. INTRODUCTION

The protection factor (PF) computational procedure (Reference 2) of the National Fallout Shelter Survey (NFSS) used area factors to represent fractions of total floor areas offering protection greater than a predetermined value. The area factors used in the NFSS, shown in Table II, for shelters in PF Category 4-8 (PF 100 to >1000) are based on the extent of the area which does not drop below PF 100; for shelters with a center PF within PF Category 1-3 (PF 20 to 99), area factors are based on shelter areas with a perimeter PF of approximately 70 percent of the S-AREA center PF.

TABLE II

NFSS Phase 1 Area Factors

| PF Category | PF Range | Area Factor |
|---|---|---|
| 6 - 8 | 250 - over 1000 | 1.0 |
| 5 | 150 - 249 | 0.7 |
| 4 | 100 - 149 | 0.3 |
| 1 - 3 | 20 - 99 | 0.5 |

This chapter presents analyses of the effects of building characteristics and combinations of ground and roof contributions on the usable shelter area of a building.

## II. LIMITATIONS OF NFSS AREA FACTORS

The NFSS area factors represent usable areas in the first story of a windowless square building receiving only ground contribution. A previous RTI evaluation of area factors under OCD Subtask 1115A (Reference 1) for this type of structure indicated that the area factors presented in Table II are significantly conservative (from .1 to .2 added for each factor) when compared to results of the Engineering Manual procedure (Reference 4).

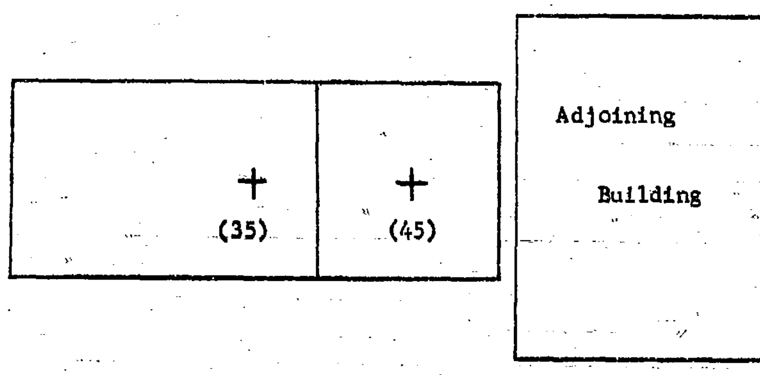
For the intended objective of determining gross estimates of the total number of available shelter spaces by machine methods, the area factor approach is excellent. However, a careful analysis of each building in question should be made before final determination of the actual area of the shelter is made. The considerations that must be made for an actual building are:

1. Center PF - All applications of area factors are based on the PF at the center of a building. This means that if the center PF is not in PF Category 2-8, no area factor is applied and the entire story is considered to have a PF less than the center PF. In reality, this assumption may be wrong. Because of mutual shielding, irregularly spaced interior partitions, grade level, etc., the PF might be higher at the end of a building story than at the center. An illustration of a basement with a center PF possibly less than the off-center PF is given in Figure 3.
2. Interior Partitions - If a building contains interior partitions, the PF may drop rapidly outside the area bounded by partitions. In Phase 1 of the NFSS the location of partitions was not given unless a core was reported. A core is defined in Reference 5 as "a central portion of a story surrounded on two or more sides by interior partitions of heavy construction." Cores were reported in Phase 1 for only the first and second stories of a building and allowed only one partition per building side to be noted.

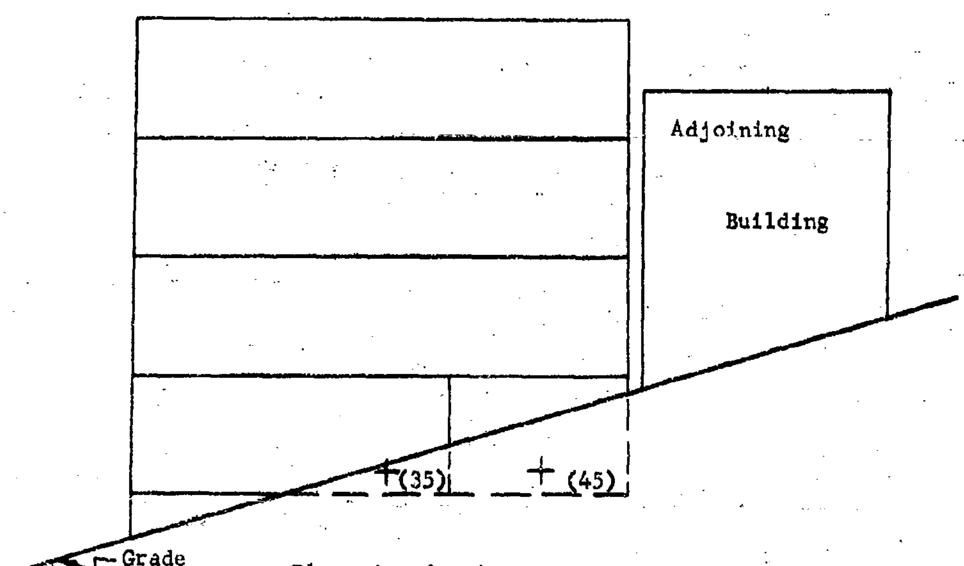
FIGURE 3

Basement with Center PF Less than Off-Center PF

(PF's in Parentheses)




Plan View




Elevation Section

The area factor for a building with a core area or any interior partitions may be quite different from one for a building with no partitions. For example, if the area bounded by partitions in a story with a center PF in Category 4 is greater than .3 (Category 4 area factor) of the total floor area, the area of the shelter very likely extends to the partitions rather than just .3 of the total area. It is shown in Chapter 1 that approximately 78 percent of the NFSS Phase 2 upper story shelter areas have parallel partitions. This in itself is reason to believe that substantial increases in total shelter area might be gained through use of a PF computational procedure that would consider the location of interior partitions and give PF results at points other than the center of the building.

3. Floor Thickness - The majority of buildings in the NFSS and all those surveyed by RTI are exposed to limited planes of contamination. An RTI statistical study of NFSS Phase 1 data (Reference 1) indicated the modal width of the total planes of contamination contributing to a shelter story to be less than 60 feet for every PF category. Because of these narrow planes of contamination, the thickness of floors for stories above grade is an important parameter to consider when determining the total area of the shelter. Due to the narrow planes of contamination, ground contribution to stories above grade often must penetrate the floor below the detector. The PF is therefore quite dependent on the mass thickness of the floor through which the radiation must penetrate. For example, for a plane less than 300 feet wide, Technical Operations Research determined that the dose rate at an upper story corner position in a windowless building with light floors ($X_f$ = 20 psf) was 1.4 times that at the center position whereas it was 2.5 times greater than that at the center for thick floors ($X_f$ = 80 psf) (See Table 42 of Reference 6).

4. Apertures - Previous RTI analyses of aperture contributions in a square building indicated that the usable area of a shelter depends on the percentage of apertures (Reference 1). For example, on the second floor of a 5000 square foot hypothetical building with a center PF of 125, the fraction of the area having a protection factor greater than 100 is 0.43 with no apertures and increases to 0.56 with 10 percent apertures. When apertures were added, the wall mass thickness was increased to maintain a center PF of 125.

5. Roof Contribution - In shelters where the predominant contribution comes from ground sources surrounding the building, the center of an above-ground shelter should be the point with the highest PF. The PF would decrease closer to the exterior wall. However, when roof or ceiling contribution is also present, the shelter may be quite different in size and location from that with no such contribution. For example, with the predominant contribution coming from the roof, the safest area would be closest to the exterior wall and the PF would decrease as the center is approached. Upper stories of high rise buildings, as well as basements, are shelter areas where roof contribution can often exceed ground contribution.

## III. RTI INVESTIGATIONS

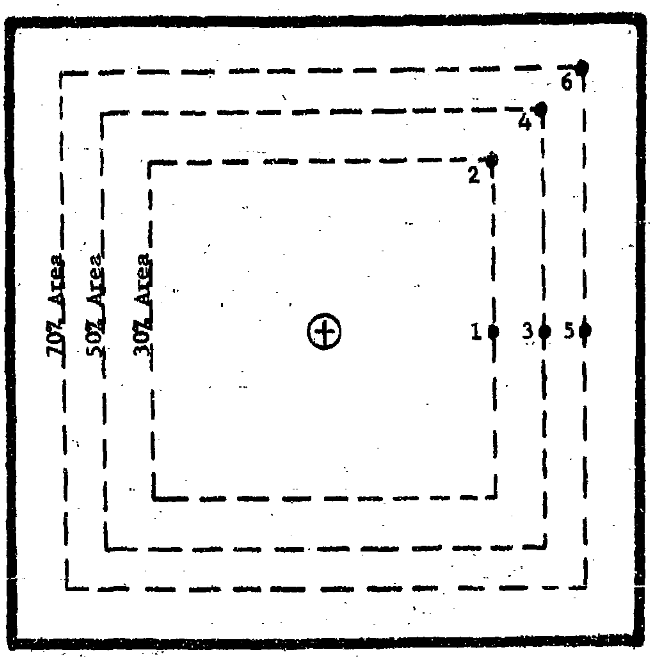
### A. Method of Approach

Using Engineering Manual and AE Guide (Reference 7) procedures, RTI made numerous computations to determine the range of PF's in various size buildings subjected to combinations of roof and ground contributions. After the exterior wall mass thickness giving a desired center PF in a building was determined, computations were made for 6 other points in the building as illustrated in Figure 4.

Points 1 and 2, 3 and 4, and 5 and 6 are on the perimeter of areas arbitrarily taken to be equivalent to 30, 50, and 70 percent, respectively, of the total building area. These points are located at approximately 54.8, 70.7, and 83.7 percent of the distance from the center perpendicular to the exterior wall and from the center to the corner.

FIGURE 4

Detector Locations for Area Factor Computations



Roof contributions were determined by the Engineering Manual Method; ground contributions by the AE Guide which assumes all areas to be square. Calculations were made for buildings with the characteristics given in Appendix B.

B. Findings

1. Roof Contribution Only

Using the same structural data required to give a desired PF in the center of a square building, Engineering Manual PF computations were made for the 6 points shown in Figure 4. These data were then plotted as illustrated in Figure 5 in order to determine by interpolation the boundaries of the area with a selected PF. The illustration shows the distances from the center of a 10,000 square foot building to points where the PF reaches 100 on a line perpendicular to the exterior wall (line through points 1, 3, and 5 of Figure 4) and on a diagonal line (points 2, 4, and 6).

These points determine the boundaries of the area having a PF of at least 100 within a building story and it was thus possible to calculate the area of the shelter. For the case of all roof contribution the shelter is adjacent to the exterior walls and not in the center of the building. Very little variation was noted in the usable shelter, expressed as a percent of the total area, for buildings in the 2,500 - 10,000 square foot range.

Conservative area factors for buildings with all roof contribution are given in Table III and they are graphically presented in Figure 6. These area factors may also be used for rectangular shaped buildings when the AE Guide procedure, which does not consider the building shape, is used. This is because a rectangular building with the same area and construction characteristics as a square building will have less roof contribution.

FIGURE 5

Variation of PF with Detector Location - All Roof Contribution

(10,000 Square Foot Building - Center PF of 85)

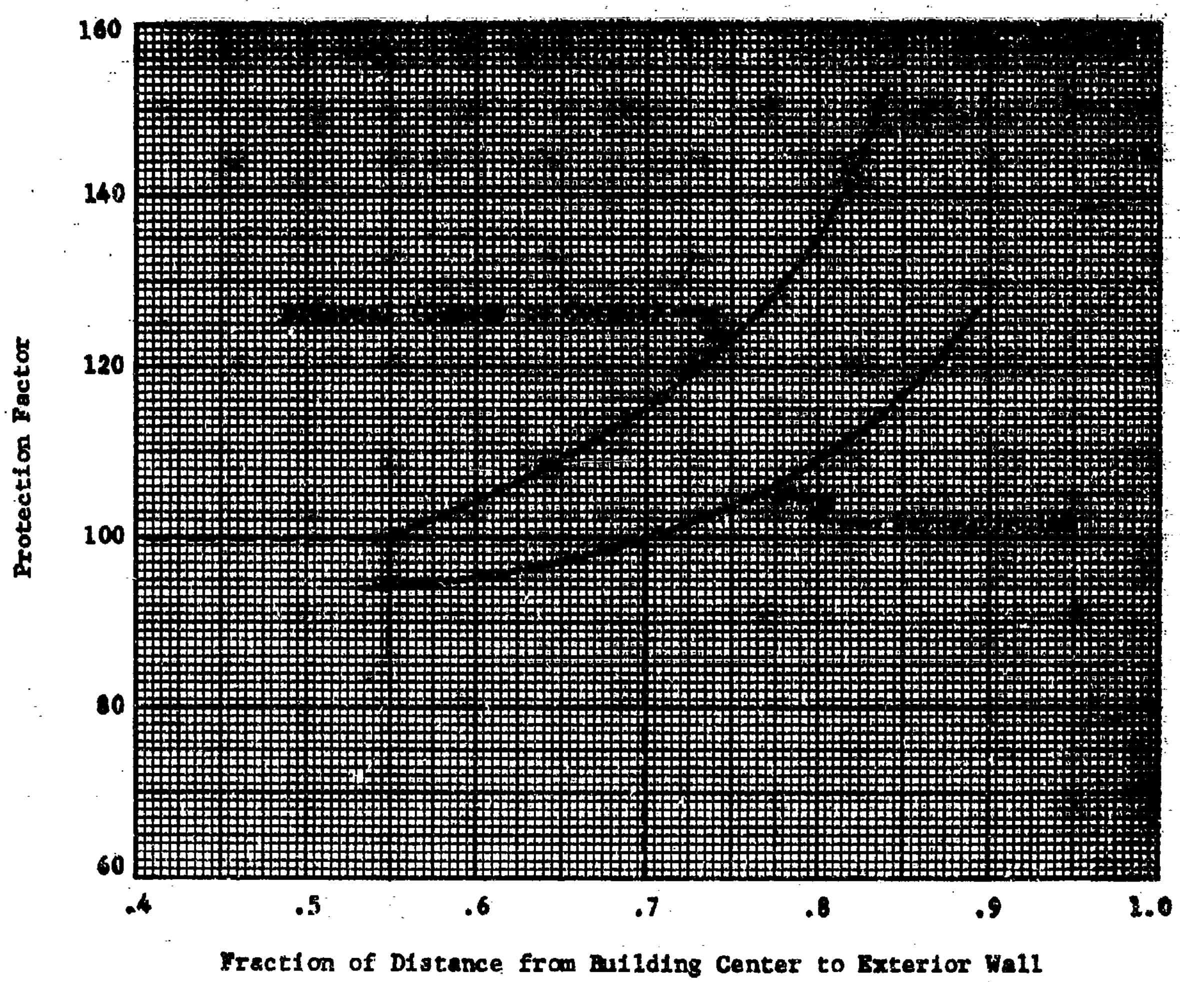


FIGURE 6

Area Factors - Roof Contribution Only

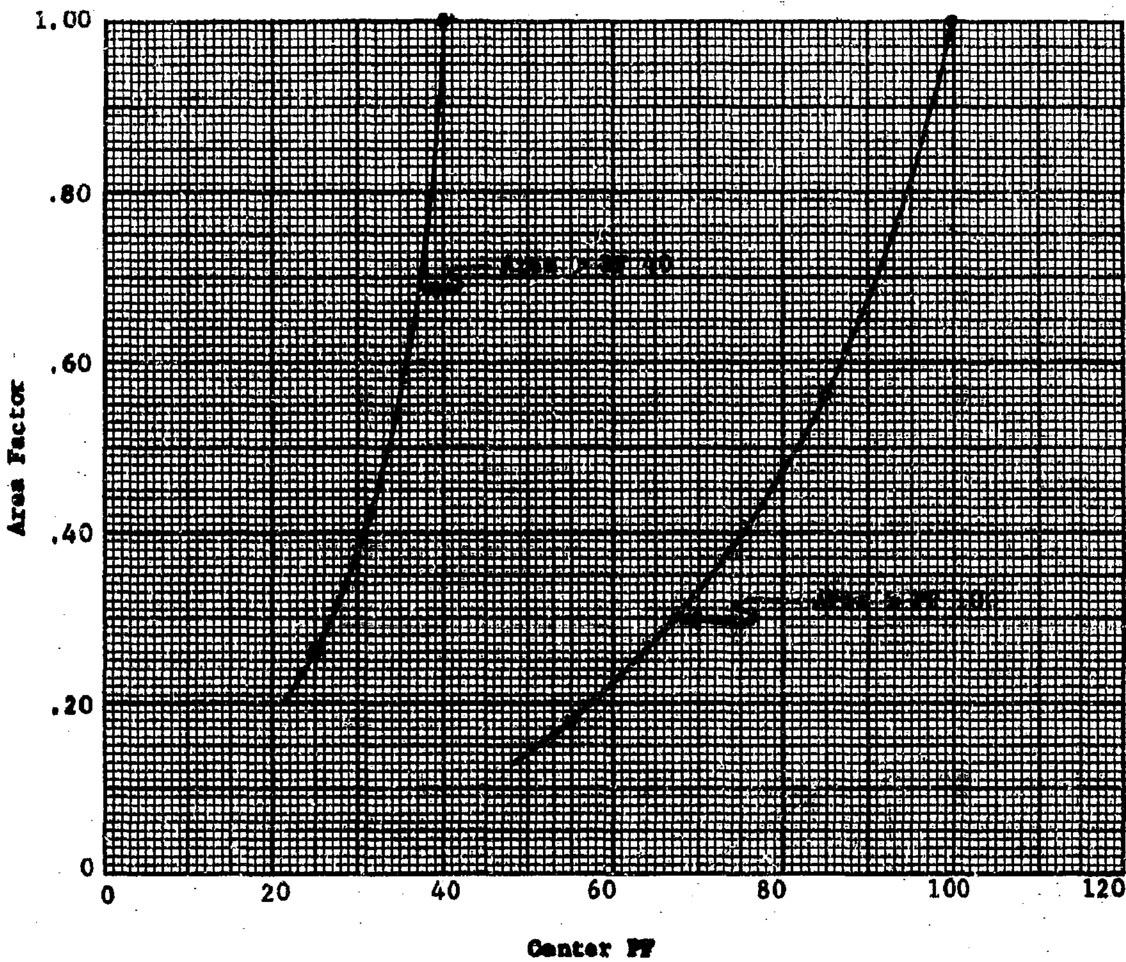


TABLE III

Area Factors - Roof Contribution Only

| | PF Category | Area Factor |
|---|---|---|
| Area Greater Than PF 100 | 4 - 8 | 1.00 |
| | 3 | .56 |
| | 2 | .18 |
| Area Greater than PF 40 | 2 - 8 | 1.00 |
| | 1 | .26 |

If the center PF is known, it is possible to find the approximate boundaries of any shelter area through the use of Figure 6. It is important to note that shelter areas with a center PF less than 40 and receiving predominantly roof contribution still have considerable area of PF 40 or better.

2. Ground and Roof Contribution

Most stories of structures receive some combination of ground and roof contribution. Therefore, area factors for this type of structure are very important in determining the shelter area of a story.

Various combinations of ground and roof contributions, ranging from all ground to all roof, were calculated for upper stories of the hypothetical buildings described in Appendix B. The contributions for each building size and center PF were plotted as shown in Figure 7. This figure illustrates the variations in PF on a line from the center perpendicular to the exterior wall in a 10,000 square foot area with a center PF of 85. Similar graphs were prepared for PF's on a line from the center of the building to the corner of the building. The boundaries of shelter area within a given PF range were then determined from these charts.

As was found for all roof contribution, the shelter areas were fairly insensitive to changes in total building area. Therefore, conservative data were again used and are presented in Figure 8 to show the area of a

FIGURE 7

<u>Variation of PF with Detector Location and Dose Source</u>

(10,000 Square Foot Building - Center PF of 85)

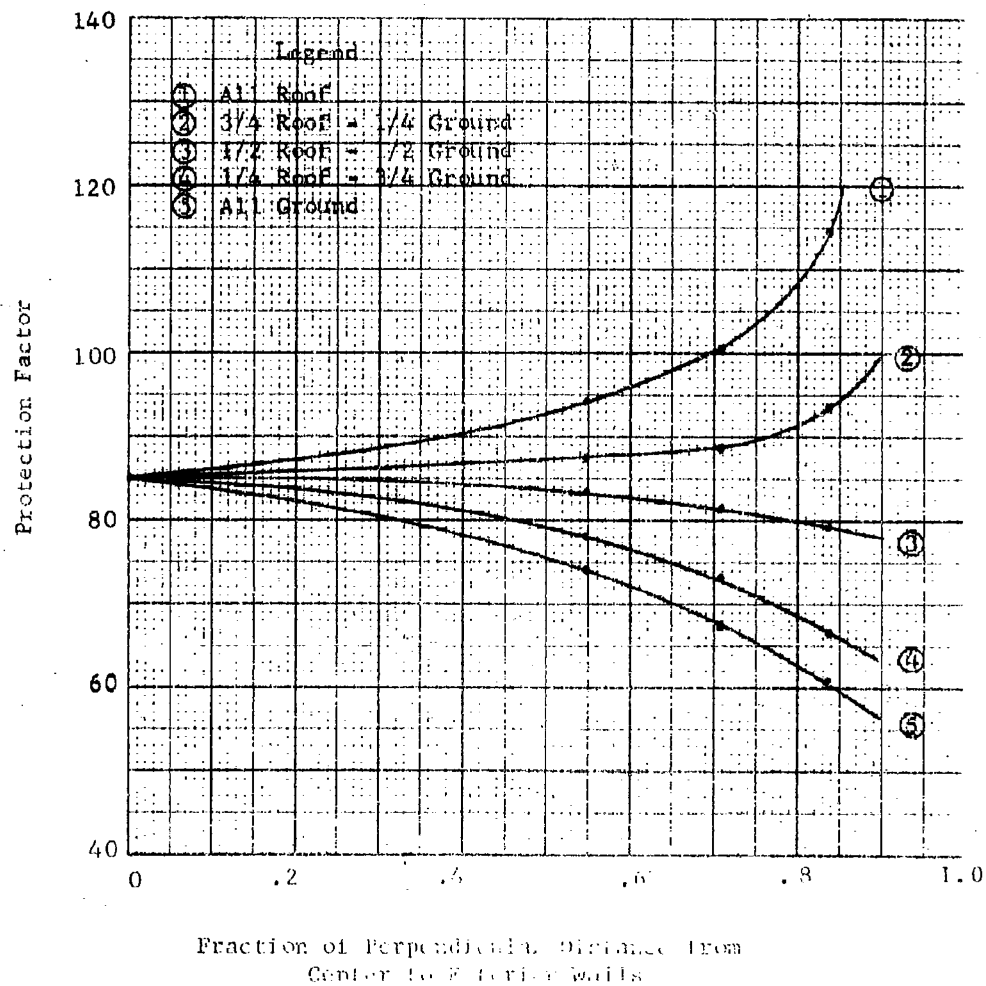
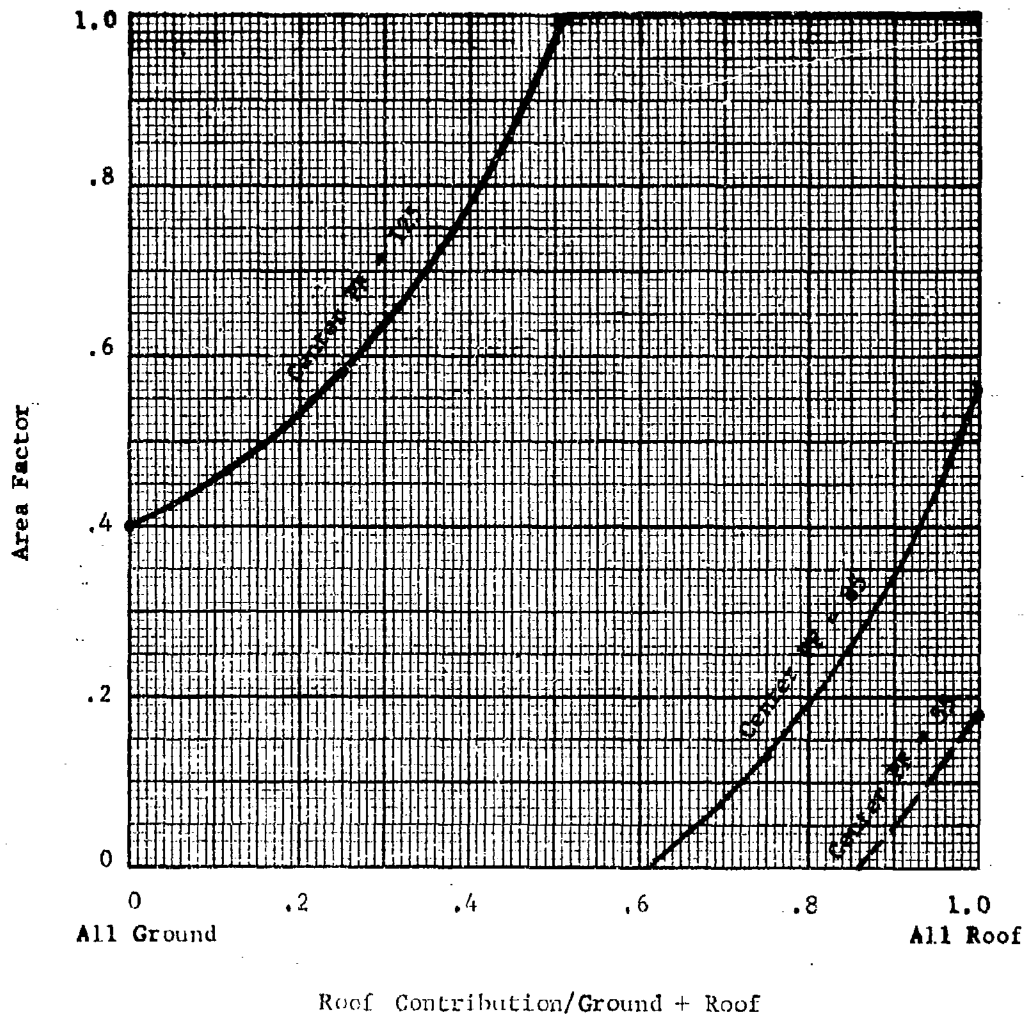


FIGURE 8

Area Factors - Ground and Roof Contribution

(Areas Greater than PF 100)

Note: For center PF's less than 100, the shelter area is closest to the exterior walls.



story with a PF of 100 or better when exposed to infinite planes of contamination. This figure shows the area factors for any combination of ground and roof contribution when the center PF is known. This is therefore a very valuable figure for use with a simplified procedure such as the AE Guide.

## IV. RECOMMENDATIONS

For simplified hand computational procedures where only a center PF is generally calculated, it is recommended that Figure 8 be used to determine the area with a PF of 100 or more.

Due to the complexities of the combined effects of apertures, interior partitions, floor thickness, etc., the area of shelter in buildings of similar size with the same center PF can be quite different. The PF computational procedure which has been programmed by RTI under Contract No. OCD-PS-64-65 for use on a Control Data Corporation CDC 3600 Computer therefore does not use predetermined area factors. The PF is calculated at the center and at 8 predetermined off-center detector locations, which allows the computer to determine the approximate areas of a building having a PF of a predetermined value. The effect of each of the above characteristics is therefore considered in each building.

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7. Office of Civil Defense. Fallout Shelter Surveys: Guide for Architects and Engineers. Washington: Office of Civil Defense, Department of Defense, December 1961.

## Appendix A

### Shelter Area and Building Part Tabulations by Phase 2 Technical Shielding Characteristics

This appendix presents in tabular form the categorization of the Phase 2 structural data for a statistical sample of 844 buildings. Shelter areas and building parts are categorized by areaways, aperture sill height, and interior partitions. These data are presented in tables in the following order:

Areaways

| | |
|---|---|
| TABLE A-I | Building Parts with Areaways Reported |
| TABLE A-II | Areaways - All PF Categories |
| TABLE A-III | Areaways for PF Category 2 Shelter Areas |
| TABLE A-IV | Areaways for PF Category 3 Shelter Areas |
| TABLE A-V | Areaways for PF Category 4 Shelter Areas |
| TABLE A-VI | Areaways for PF Category 5 Shelter Areas |
| TABLE A-VII | Areaways for PF Category 6 Shelter Areas |
| TABLE A-VIII | Areaways for PF Category 7 Shelter Areas |
| TABLE A-IX | Areaways for PF Category 8 Shelter Areas |

Aperture Sill Heights

| | |
|---|---|
| TABLE A-X | Shelter Areas with Sill Heights Reported |
| TABLE A-XI | Sill Heights in Basement Shelter Areas |
| TABLE A-XII | Sill Heights in First Story Shelter Areas |
| TABLE A-XIII | Sill Heights in Upper Story Shelter Areas |

Parallel Partitions

| | |
|---|---|
| TABLE A-XIV | Shelter Areas with Parallel Partitions Reported |
| TABLE A-XV | Parallel Partitions in Basement Shelter Areas |
| TABLE A-XVI | Parallel Partitions in First Story Shelter Areas |
| TABLE A-XVII | Parallel Partitions in Upper Story Shelter Areas |

Cross Partitions

TABLE A-I

Building Parts with Areaways Reported

(1167 Building Parts)

| PF Category | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| Number | 86 | 39 | 80 | 42 | 36 | 17 | 37 | 337 |
| Fraction of Total Building Parts | .0737 | .0334 | .0686 | .0360 | .0308 | .0146 | .0317 | .2888 |

TABLE A-II

Areaways - All PF Categories

| Percent of Building Side Length | Areaway Width (in feet) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | > 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NUMBER | | | | | | |
| 0 | 1 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 7 |
| 10 | 18 | 64 | 38 | 9 | 8 | 1 | 2 | 1 | 2 | 2 | 145 |
| 20 | 13 | 45 | 27 | 13 | 5 | 4 | 3 | 2 | 3 | 5 | 120 |
| 30 | 7 | 23 | 9 | 8 | 2 | 1 | 0 | 0 | 0 | 4 | 54 |
| 40 | 2 | 5 | 10 | 3 | 0 | 0 | 0 | 1 | 2 | 1 | 24 |
| 50 | 1 | 9 | 10 | 5 | 0 | 0 | 0 | 1 | 1 | 2 | 29 |
| 60 | 0 | 5 | 4 | 8 | 3 | 0 | 1 | 0 | 1 | 3 | 25 |
| 70 | 0 | 4 | 3 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 11 |
| 80 | 0 | 2 | 6 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 13 |
| 90 | 2 | 11 | 14 | 22 | 4 | 2 | 1 | 1 | 2 | 6 | 65 |
| | | | | | | | | | | | 493 |
| | | | | | FRACTION | | | | | | |
| 0 | .0020 | .0041 | .0041 | .0020 | .0020 | 0 | 0 | 0 | 0 | 0 | .0142 |
| 10 | .0365 | .1298 | 0771 | .0183 | .0162 | .0020 | .0041 | .0020 | .0041 | .0041 | .2942 |
| 20 | .0264 | .0913 | 0548 | .0264 | .0101 | .0081 | .0061 | .0041 | .0061 | .0101 | .2434 |
| 30 | .0142 | .0467 | 0183 | .0162 | .0041 | .0020 | 0 | 0 | 0 | .0081 | .1095 |
| 40 | .0041 | .0101 | 0203 | .0061 | 0 | 0 | 0 | .0020 | .0041 | .0020 | .0487 |
| 50 | .0020 | .0183 | .0203 | .0101 | 0 | 0 | 0 | .0020 | .0020 | .0041 | .0588 |
| 60 | 0 | .0101 | .0081 | .0162 | .0061 | 0 | .0020 | 0 | .0020 | .0061 | .0507 |
| 70 | 0 | .0081 | .0061 | .0041 | .0020 | 0 | .0020 | 0 | 0 | 0 | .0223 |
| 80 | 0 | .0041 | .0122 | .0081 | .0020 | 0 | 0 | 0 | 0 | 0 | .0264 |
| 90 | .0041 | .0223 | .0284 | .0446 | .0081 | .0041 | .0020 | .0020 | .0041 | .0122 | .1318 |
| | | | | | | | | | | | 1.0000 |

TABLE A-III

Areaways for PF Category 2 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10 | 7 | 12 | 11 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 35 |
| 20 | 9 | 10 | 7 | 4 | 0 | 3 | 0 | 0 | 0 | 2 | 35 |
| 30 | 5 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 12 |
| 40 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 |
| 50 | 1 | 3 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 60 | 0 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 4 |
| 70 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 0 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 5 |
| 90 | 1 | 2 | 4 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 13 |
| | | | | | | | | | | | 117 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | 0 | 0 | .0085 | 0 | 0 | 0 | 0 | 0 | 0 | .0085 |
| 10 | .0600 | .1026 | .0940 | .0171 | 0 | 0 | 0 | .0085 | 0 | .0171 | .2992 |
| 20 | .0770 | .0855 | .0600 | .0342 | 0 | .0256 | 0 | 0 | 0 | .0171 | .2992 |
| 30 | .0427 | .0427 | .0085 | 0 | 0 | 0 | 0 | 0 | 0 | .0085 | .1026 |
| 40 | .0085 | .0085 | .0171 | 0 | 0 | 0 | 0 | 0 | 0 | .0085 | .0427 |
| 50 | .0085 | .0256 | 0 | .0171 | 0 | 0 | 0 | 0 | 0 | 0 | .0513 |
| 60 | 0 | .0171 | 0 | 0 | .0085 | 0 | .0085 | 0 | 0 | 0 | .0342 |
| 70 | 0 | 0 | .0085 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0085 |
| 80 | 0 | 0 | .0256 | .0085 | .0085 | 0 | 0 | 0 | 0 | 0 | .0427 |
| 90 | .0085 | .0171 | .0342 | .0256 | .0085 | .0085 | 0 | 0 | 0 | .0085 | .1111 |
| | | | | | | | | | | | 1.0000 |

TABLE A-IV

Areaways for PF Category 3 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 | Total |
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 5 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 9 |
| 20 | 0 | 6 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 11 |
| 30 | 0 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 40 | 0 | 1 | 2 | 3 | 0 | 0 | 0 | 1 | 0 | 0 | 7 |
| 50 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 6 |
| 60 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 3 |
| 70 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 90 | 0 | 3 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 9 |
| | | | | | | | | | | | 52 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | .0962 | .0192 | .0192 | .0385 | 0 | 0 | 0 | 0 | 0 | .1731 |
| 20 | 0 | .1154 | .0385 | .0385 | 0 | 0 | 0 | 0 | 0 | .0192 | .2115 |
| 30 | 0 | .0385 | .0192 | .0192 | 0 | 0 | 0 | 0 | 0 | 0 | .0769 |
| 40 | 0 | .0192 | .0385 | .0577 | 0 | 0 | 0 | .0192 | 0 | 0 | .1346 |
| 50 | 0 | 0 | .0577 | .0192 | 0 | 0 | 0 | .0192 | 0 | .0192 | .1154 |
| 60 | 0 | .0385 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0192 | .0577 |
| 70 | 0 | .0192 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0192 |
| 80 | 0 | .0192 | .0192 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0385 |
| 90 | 0 | .0577 | .0192 | .0192 | .0192 | .0192 | 0 | 0 | 0 | .0385 | .1731 |
| | | | | | | | | | | | 1.0000 |

TABLE A-V

Areaways for PF Category 4 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 | Total |
| | | | | | NUMBER | | | | | | |
| 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 3 |
| 10 | 6 | 12 | 13 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 35 |
| 20 | 1 | 9 | 6 | 4 | 2 | 1 | 0 | 1 | 0 | 1 | 25 |
| 30 | 0 | 6 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 40 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 50 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| 60 | 0 | 0 | 2 | 6 | 2 | 0 | 0 | 0 | 1 | 1 | 12 |
| 70 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 4 |
| 80 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 90 | 1 | 4 | 7 | 8 | 1 | 0 | 1 | 1 | 1 | 0 | 24 |
| | | | | | | | | | | | 124 |
| | | | | | FRACTION | | | | | | |
| 0 | .0081 | 0 | .0081 | 0 | .0081 | 0 | 0 | 0 | 0 | 0 | .0242 |
| 10 | .0484 | .0968 | .1048 | .0161 | .0161 | 0 | 0 | 0 | 0 | 0 | .2822 |
| 20 | .0081 | .0726 | .0484 | .0323 | .0161 | .0081 | 0 | .0081 | 0 | .0081 | .2016 |
| 30 | 0 | .0484 | .0242 | .0242 | 0 | 0 | 0 | 0 | 0 | 0 | .0968 |
| 40 | 0 | 0 | .0161 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0161 |
| 50 | 0 | 0 | .0161 | .0081 | 0 | 0 | 0 | 0 | .0081 | 0 | .0323 |
| 60 | 0 | 0 | .0161 | .0484 | .0161 | 0 | 0 | 0 | .0081 | .0081 | .0968 |
| 70 | 0 | .0081 | .0081 | 0 | .0081 | 0 | .0081 | 0 | 0 | 0 | .0323 |
| 80 | 0 | 0 | .0081 | .0161 | 0 | 0 | 0 | 0 | 0 | 0 | .0242 |
| 90 | .0081 | .0323 | .0565 | .0645 | .0081 | 0 | .0081 | .0081 | .0081 | 0 | .1935 |
| | | | | | | | | | | | 1.0000 |

TABLE A-VI

Areaways for PF Category 5 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | > 10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 10 | 1 | 9 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 13 |
| 20 | 2 | 5 | 4 | 2 | 0 | 0 | 1 | 0 | 1 | 0 | 15 |
| 30 | 1 | 7 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 40 | 1 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 50 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 60 | 0 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 70 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 90 | 0 | 0 | 1 | 7 | 1 | 0 | 0 | 0 | 0 | 2 | 11 |
| | | | | | | | | | | | 64 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | .0156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0156 |
| 10 | .0156 | .1406 | .0156 | 0 | .0156 | 0 | 0 | 0 | .0156 | 0 | .2031 |
| 20 | .0313 | .0781 | .0625 | .0313 | 0 | 0 | .0156 | 0 | .0156 | 0 | .2344 |
| 30 | .0156 | .1094 | .0313 | .0313 | 0 | 0 | 0 | 0 | 0 | 0 | .1875 |
| 40 | .0156 | .0313 | .0156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0625 |
| 50 | 0 | 0 | .0313 | .0156 | 0 | 0 | 0 | 0 | 0 | 0 | .0469 |
| 60 | 0 | .0156 | 0 | .0313 | 0 | 0 | 0 | 0 | 0 | 0 | .0469 |
| 70 | 0 | 0 | 0 | .0156 | 0 | 0 | 0 | 0 | 0 | 0 | .0156 |
| 80 | 0 | 0 | .0156 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0156 |
| 90 | 0 | 0 | .0156 | .1094 | .0156 | 0 | 0 | 0 | 0 | .0313 | .1719 |
| | | | | | | | | | | | 1.0000 |

TABLE A-VII

Areaways for PF Category 6 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | > 10 | Total |
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 1 | 14 | 8 | 1 | 3 | 0 | 0 | 0 | 0 | 0 | 27 |
| 20 | 1 | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 11 |
| 30 | 1 | 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 8 |
| 40 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| 50 | 0 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 60 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 0 | 4 |
| | | | | | | | | | | | 57 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | .0175 | .2456 | .1404 | .0175 | .0526 | 0 | 0 | 0 | 0 | 0 | .4736 |
| 20 | .0175 | .1228 | .0175 | .0175 | 0 | 0 | 0 | 0 | .0175 | 0 | .1930 |
| 30 | .0175 | .0351 | .0351 | 0 | .0175 | 0 | 0 | 0 | 0 | .0351 | .1404 |
| 40 | 0 | 0 | .0175 | 0 | 0 | 0 | 0 | 0 | .0175 | 0 | .0351 |
| 50 | 0 | .0351 | .0351 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0702 |
| 60 | 0 | 0 | .0175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0175 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | .0175 | .0351 | 0 | 0 | 0 | 0 | .0175 | 0 | .0702 |
| | | | | | | | | | | | 1.0000 |

TABLE A-VIII

Areaways for PF Category 7 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 20 | 0 | 3 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 7 |
| 30 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 40 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| 50 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 60 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 |
| 70 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 80 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | 22 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 10 | 0 | .1364 | .0455 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .1818 |
| 20 | 0 | .1364 | .0909 | 0 | .0455 | 0 | 0 | 0 | .0455 | 0 | .3182 |
| 30 | 0 | 0 | 0 | .0455 | 0 | 0 | 0 | 0 | 0 | .0455 | .0909 |
| 40 | 0 | 0 | .0455 | 0 | 0 | 0 | 0 | 0 | .0455 | 0 | .0909 |
| 50 | 0 | .0455 | .0455 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0909 |
| 60 | 0 | 0 | .0455 | 0 | 0 | 0 | 0 | 0 | 0 | .0455 | .0909 |
| 70 | 0 | .0455 | 0 | .0455 | 0 | 0 | 0 | 0 | 0 | 0 | .0909 |
| 80 | 0 | .0455 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0455 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | | | | 1.0000 |

TABLE A-IX

Areaways for PF Category 8 Shelter Areas

| Percent of Building Side Length | Areaway Width (in feet) 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | >10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | NUMBER | | | | | | |
| 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 10 | 3 | 9 | 3 | 3 | 0 | 1 | 2 | 0 | 1 | 0 | 22 |
| 20 | 0 | 5 | 5 | 0 | 2 | 0 | 2 | 1 | 0 | 1 | 16 |
| 30 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 4 |
| 40 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 50 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 80 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 90 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| | | | | | | | | | | | 57 |
| | | | | | FRACTION | | | | | | |
| 0 | 0 | .0175 | .0175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0351 |
| 10 | .0526 | .1579 | .0526 | .0526 | 0 | .0175 | .0351 | 0 | .0175 | 0 | .3859 |
| 20 | 0 | .0877 | .0877 | 0 | .0351 | 0 | .0351 | .0175 | 0 | .0175 | .2807 |
| 30 | 0 | .0175 | 0 | .0175 | .0175 | .0175 | 0 | 0 | 0 | 0 | .0702 |
| 40 | 0 | .0175 | .0175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0351 |
| 50 | 0 | .0526 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0175 | .0702 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | .0175 | .0175 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | .0351 |
| 80 | 0 | 0 | 0 | .0175 | 0 | 0 | 0 | 0 | 0 | 0 | .0175 |
| 90 | 0 | .0351 | 0 | .0175 | 0 | 0 | 0 | 0 | 0 | .0175 | .0702 |
| | | | | | | | | | | | 1.0000 |

TABLE A-X

Shelter Areas with Sill Heights Reported

| PF Category | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| **Basement Shelter Areas** | | | | | | | | |
| Number | 161 | 77 | 143 | 91 | 69 | 32 | 52 | 625 |
| Fraction of Total (1030) Basement Shelter Areas | .1563 | .0748 | .1388 | .0883 | .0670 | .0311 | .0505 | .6068 |
| **First Story Shelter Areas** | | | | | | | | |
| Number | 84 | 23 | 53 | 24 | 11 | 5 | 6 | 206 |
| Fraction of Total (262) First Story Shelter Areas | .3206 | .0878 | .2023 | .0916 | .0420 | .0191 | .0229 | .7863 |
| **Upper Story Shelter Areas** | | | | | | | | |
| Number | 214 | 91 | 245 | 121 | 93 | 29 | 26 | 819 |
| Fraction of Total (838) Upper Story Shelter Areas | .2554 | .1086 | .2924 | .1444 | .1110 | .0346 | .0310 | .9762 |

TABLE A-XI

Sill Heights in Basement Shelter Areas

| Sill Height | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | **NUMBER** | | | | | | | |
| 0 | 8 | 1 | 1 | 4 | 0 | 0 | 3 | 17 |
| 1 | 3 | 2 | 4 | 1 | 3 | 3 | 0 | 16 |
| 2 | 5 | 6 | 11 | 5 | 7 | 3 | 2 | 39 |
| 3 | 21 | 10 | 18 | 16 | 7 | 2 | 11 | 85 |
| 4 | 25 | 11 | 19 | 13 | 12 | 2 | 14 | 96 |
| 5 | 49 | 24 | 38 | 26 | 12 | 5 | 6 | 160 |
| 6 | 35 | 11 | 28 | 15 | 14 | 5 | 9 | 117 |
| 7 | 8 | 7 | 11 | 6 | 5 | 1 | 2 | 40 |
| 8 | 6 | 3 | 6 | 2 | 2 | 6 | 3 | 28 |
| 9 | 1 | 2 | 7 | 3 | 7 | 5 | 2 | 27 |
| | | | | | | | | 625 |
| | **FRACTION** | | | | | | | |
| 0 | .0128 | .0016 | .0016 | .0064 | 0 | 0 | .0048 | .0272 |
| 1 | .0048 | .0032 | .0064 | .0016 | .0048 | .0048 | 0 | .0256 |
| 2 | .0080 | .0096 | .0176 | .0080 | .0112 | .0048 | .0032 | .0624 |
| 3 | .0336 | .0160 | .0288 | .0256 | .0112 | .0032 | .0176 | .1360 |
| 4 | .0400 | .0176 | .0304 | .0208 | .0192 | .0032 | .0224 | .1536 |
| 5 | .0784 | .0384 | .0608 | .0416 | .0192 | .0080 | .0096 | .2560 |
| 6 | .0560 | .0176 | .0448 | .0240 | .0224 | .0080 | .0144 | .1872 |
| 7 | .0128 | .0112 | .0176 | .0096 | .0080 | .0016 | .0032 | .0640 |
| 8 | .0096 | .0048 | .0096 | .0032 | .0032 | .0096 | .0048 | .0448 |
| 9 | .0016 | .0032 | .0112 | .0048 | .0112 | .0080 | .0032 | .0432 |
| | | | | | | | | 1.0000 |

## TABLE A-XII

### Sill Heights in First Story Shelter Areas

| Sill Height | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | **NUMBER** | | | | |
| 0 | 11 | 0 | 3 | 3 | 0 | 0 | 0 | 17 |
| 1 | 3 | 1 | 2 | 0 | 0 | 0 | 0 | 6 |
| 2 | 19 | 3 | 11 | 4 | 0 | 0 | 1 | 38 |
| 3 | 31 | 13 | 18 | 10 | 3 | 4 | 1 | 80 |
| 4 | 13 | 4 | 15 | 4 | 6 | 1 | 3 | 46 |
| 5 | 1 | 1 | 2 | 2 | 1 | 0 | 0 | 7 |
| 6 | 2 | 1 | 1 | 1 | 0 | 0 | 1 | 6 |
| 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 2 | 0 | 1 | 0 | 1 | 0 | 0 | 4 |
| | | | | | | | | 206 |
| | | | | **FRACTION** | | | | |
| 0 | .0534 | 0 | .0146 | .0146 | 0 | 0 | 0 | .0825 |
| 1 | .0146 | .0049 | .0097 | 0 | 0 | 0 | 0 | .0291 |
| 2 | .0922 | .0146 | .0534 | .0194 | 0 | 0 | .0049 | .1845 |
| 3 | .1505 | .0631 | .0874 | .0485 | .0146 | .0194 | .0049 | .3884 |
| 4 | .0631 | .0194 | .0728 | .0194 | .0291 | .0049 | .0146 | .2233 |
| 5 | .0049 | .0049 | .0097 | .0097 | .0049 | 0 | 0 | .0340 |
| 6 | .0097 | .0049 | .0049 | .0049 | 0 | 0 | .0049 | .0291 |
| 7 | .0097 | 0 | 0 | 0 | 0 | 0 | 0 | .0097 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | .0097 | 0 | .0049 | 0 | .0049 | 0 | 0 | .0194 |
| | | | | | | | | 1.0000 |

TABLE A-XIII

Sill Heights in Upper Story Shelter Areas

| Sill Height | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 3 |
| 1 | 5 | 4 | 1 | 2 | 5 | 3 | 0 | 20 |
| 2 | 95 | 48 | 118 | 60 | 40 | 17 | 23 | 401 |
| 3 | 99 | 34 | 107 | 51 | 37 | 9 | 2 | 339 |
| 4 | 12 | 4 | 16 | 8 | 11 | 0 | 1 | 52 |
| 5 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 4 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | 819 |
| | | | | FRACTION | | | | |
| 0 | .0024 | 0 | .0012 | 0 | 0 | 0 | 0 | .0037 |
| 1 | .0061 | .0049 | .0012 | .0024 | .0061 | .0037 | 0 | .0244 |
| 2 | .1160 | .0586 | .1441 | .0733 | .0488 | .0208 | .0281 | .4896 |
| 3 | .1209 | .0415 | .1306 | .0623 | .0452 | .0110 | .0024 | .4139 |
| 4 | .0147 | .0049 | .0195 | .0098 | .0134 | 0 | .0012 | .0635 |
| 5 | .0012 | .0012 | .0024 | 0 | 0 | 0 | 0 | .0049 |
| 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | 1.0000 |

TABLE A-XIV

Shelter Areas with Parallel Partitions Reported

| PF Category | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| **Basement Shelter Areas** | | | | | | | | |
| Number | 109 | 47 | 103 | 72 | 67 | 32 | 95 | 525 |
| Fraction of Total (1030) Basement Shelter Areas | .1058 | .0456 | .1000 | .0699 | .0650 | .0311 | .0922 | .5097 |
| **First Story Shelter Areas** | | | | | | | | |
| Number | 60 | 21 | 50 | 20 | 11 | 6 | 10 | 178 |
| Fraction of Total (262) First Story Shelter Areas | .2290 | .0802 | .1908 | .0763 | .0420 | .0229 | .0382 | .6794 |
| **Upper Story Shelter Areas** | | | | | | | | |
| Number | 149 | 68 | 209 | 105 | 72 | 26 | 27 | 656 |
| Fraction of Total (838) Upper Story Shelter Areas | .1778 | .0811 | .2494 | .1253 | .0859 | .0310 | .0322 | .7828 |

TABLE A-XV

Parallel Partitions in Basement Shelter Areas

| Average psf per Shelter Area | PF Category | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| | | | | NUMBER | | | | |
| 5 | 13 | 7 | 6 | 2 | 6 | 1 | 6 | 41 |
| 10 | 13 | 5 | 9 | 7 | 10 | 3 | 7 | 54 |
| 15 | 12 | 4 | 10 | 14 | 5 | 3 | 10 | 58 |
| 20 | 25 | 10 | 13 | 11 | 11 | 5 | 20 | 95 |
| 25 | 4 | 2 | 3 | 4 | 1 | 0 | 6 | 20 |
| 30 | 4 | 2 | 10 | 5 | 7 | 3 | 9 | 40 |
| 35 | 6 | 1 | 3 | 1 | 2 | 0 | 3 | 16 |
| 40 | 2 | 3 | 11 | 2 | 3 | 4 | 6 | 31 |
| 45 | 8 | 4 | 12 | 8 | 5 | 8 | 6 | 51 |
| 50 | 4 | 1 | 3 | 3 | 1 | 0 | 6 | 18 |
| 60 | 5 | 3 | 5 | 5 | 7 | 2 | 4 | 31 |
| 70 | 4 | 1 | 1 | 1 | 1 | 2 | 2 | 12 |
| 80 | 1 | 2 | 4 | 1 | 0 | 0 | 2 | 10 |
| 90 | 2 | 1 | 4 | 1 | 6 | 0 | 3 | 17 |
| 100-195 | 5 | 1 | 8 | 6 | 1 | 0 | 5 | 26 |
| 200-300 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 3 |
| >300 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| | | | | | | | | 525 |

TABLE A-XV (Continued)

| Average psf per Shelter Area | PF Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| | | | | FRACTION | | | | |
| 5 | .0248 | .0133 | .0114 | .0038 | .0114 | .0019 | .0114 | .0781 |
| 10 | .0248 | .0095 | .0171 | .0133 | .0190 | .0057 | .0133 | .1029 |
| 15 | .0229 | .0076 | .0190 | .0267 | .0095 | .0057 | .0190 | .1105 |
| 20 | .0476 | .0190 | .0248 | .0210 | .0210 | .0095 | .0381 | .1810 |
| 25 | .0076 | .0038 | .0057 | .0076 | .0019 | 0 | .0114 | .0381 |
| 30 | .0076 | .0038 | .0190 | .0095 | .0133 | .0057 | .0171 | .0762 |
| 35 | .0114 | .0019 | .0057 | .0019 | .0038 | 0 | .0057 | .0305 |
| 40 | .0038 | .0057 | .0210 | .0038 | .0057 | .0076 | .0114 | .0590 |
| 45 | .0152 | .0076 | .0229 | .0152 | .0095 | .0152 | .0114 | .0971 |
| 50 | .0076 | .0019 | .0057 | .0057 | .0019 | 0 | .0114 | .0343 |
| 60 | .0095 | .0057 | .0095 | .0095 | .0133 | .0038 | .0076 | .0590 |
| 70 | .0076 | .0019 | .0019 | .0019 | .0019 | .0038 | .0038 | .0229 |
| 80 | .0019 | .0038 | .0076 | .0019 | 0 | 0 | .0038 | .0190 |
| 90 | .0038 | .0019 | .0076 | .0019 | .0114 | 0 | .0057 | .0324 |
| 100-195 | .0095 | .0019 | .0152 | .0114 | .0019 | 0 | .0095 | .0495 |
| 200-300 | 0 | 0 | 0 | .0019 | .0019 | .0019 | 0 | .0057 |
| >300 | .0019 | 0 | .0019 | 0 | 0 | 0 | 0 | .0038 |
| | | | | | | | | 1.0000 |

TABLE A-XVI

Parallel Partitions in First Story Shelter Areas

| Average psf per Shelter Area | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | NUMBER | | | | | | | |
| 5 | 9 | 1 | 3 | 2 | 3 | 1 | 0 | 19 |
| 10 | 5 | 2 | 3 | 1 | 0 | 0 | 0 | 11 |
| 15 | 7 | 1 | 2 | 1 | 0 | 0 | 1 | 12 |
| 20 | 5 | 2 | 6 | 2 | 0 | 0 | 0 | 15 |
| 25 | 4 | 0 | 4 | 2 | 0 | 0 | 0 | 10 |
| 30 | 7 | 1 | 7 | 4 | 1 | 0 | 2 | 22 |
| 35 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 3 |
| 40 | 4 | 5 | 3 | 1 | 1 | 0 | 0 | 14 |
| 45 | 6 | 2 | 6 | 2 | 1 | 1 | 0 | 18 |
| 50 | 4 | 2 | 1 | 1 | 1 | 0 | 0 | 9 |
| 60 | 6 | 1 | 3 | 2 | 1 | 1 | 4 | 18 |
| 70 | 1 | 0 | 2 | 1 | 0 | 0 | 0 | 4 |
| 80 | 0 | 0 | 2 | 0 | 1 | 0 | 0 | 3 |
| 90 | 1 | 0 | 3 | 0 | 0 | 0 | 2 | 6 |
| 100-195 | 1 | 3 | 4 | 1 | 2 | 1 | 1 | 13 |
| 200-300 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| > 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | 178 |

TABLE A-XVI (Continued)

| Average psf per Shelter Area | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | FRACTION | | | | | | | |
| 5 | .0506 | .0056 | .0169 | .0112 | .0169 | .0056 | 0 | .1067 |
| 10 | .0281 | .0112 | .0169 | .0056 | 0 | 0 | 0 | .0618 |
| 15 | .0393 | .0056 | .0112 | .0056 | 0 | 0 | .0056 | .0674 |
| 20 | .0281 | .0112 | .0337 | .0112 | 0 | 0 | 0 | .0843 |
| 25 | .0225 | 0 | .0225 | .0112 | 0 | 0 | 0 | .0562 |
| 30 | .0393 | .0056 | .0393 | .0225 | .0056 | 0 | .0112 | .1235 |
| 35 | 0 | .0056 | .0056 | 0 | 0 | .0056 | 0 | .0169 |
| 40 | .0225 | .0281 | .0169 | .0056 | .0056 | 0 | 0 | .0787 |
| 45 | .0337 | .0112 | .0337 | .0112 | .0056 | .0056 | 0 | .1011 |
| 50 | .0225 | .0112 | .0056 | .0056 | .0056 | 0 | 0 | .0506 |
| 60 | .0337 | .0056 | .0169 | .0112 | .0056 | .0056 | .0225 | .1011 |
| 70 | .0056 | 0 | .0112 | .0056 | 0 | 0 | 0 | .0225 |
| 80 | 0 | 0 | .0112 | 0 | .0056 | 0 | 0 | .0169 |
| 90 | .0056 | 0 | .0169 | 0 | 0 | 0 | .0112 | .0337 |
| 100-195 | .0056 | .0169 | .0225 | .0056 | .0112 | .0056 | .0056 | .0730 |
| 200-300 | 0 | 0 | 0 | 0 | 0 | .0056 | 0 | .0056 |
| > 300 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | | | 1.0000 |

TABLE A-XVII

Parallel Partitions in Upper Story Shelter Areas

| Average psf per Shelter Area | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | NUMBER | | | | | | | |
| 5 | 15 | 11 | 7 | 2 | 4 | 2 | 0 | 41 |
| 10 | 19 | 7 | 8 | 1 | 4 | 1 | 4 | 44 |
| 15 | 10 | 17 | 45 | 20 | 5 | 2 | 0 | 99 |
| 20 | 34 | 8 | 26 | 16 | 11 | 5 | 14 | 114 |
| 25 | 6 | 5 | 28 | 10 | 5 | 5 | 1 | 60 |
| 30 | 11 | 7 | 39 | 17 | 7 | 1 | 0 | 32 |
| 35 | 8 | 1 | 1 | 0 | 0 | 0 | 0 | 10 |
| 40 | 16 | 3 | 21 | 10 | 2 | 0 | 2 | 54 |
| 45 | 5 | 1 | 8 | 0 | 1 | 0 | 1 | 16 |
| 50 | 12 | 5 | 2 | 3 | 2 | 0 | 0 | 24 |
| 60 | 6 | 1 | 3 | 5 | 8 | 1 | 0 | 24 |
| 70 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| 80 | 1 | 0 | 4 | 1 | 2 | 0 | 0 | 8 |
| 90 | 1 | 0 | 2 | 7 | 2 | 0 | 2 | 14 |
| 100-195 | 4 | 2 | 8 | 8 | 9 | 5 | 2 | 38 |
| 200-300 | 0 | 0 | 7 | 4 | 9 | 4 | 0 | 24 |
| > 300 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| | | | | | | | | 656 |

TABLE A-XVII (Continued)

| Average psf per Shelter Area | PF Category | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
| | | | | FRACTION | | | | |
| 5 | .0229 | .0168 | .0107 | .0030 | .0061 | .0030 | 0 | .0625 |
| 10 | .0290 | .0107 | .0122 | .0015 | .0061 | .0015 | .0061 | .0671 |
| 15 | .0152 | .0259 | .0686 | .0305 | .0076 | .0030 | 0 | .1509 |
| 20 | .0518 | .0122 | .0396 | .0244 | .0168 | .0076 | .0213 | .1739 |
| 25 | .0091 | .0076 | .0427 | .0152 | .0076 | .0076 | .0015 | .0915 |
| 30 | .0168 | .0107 | .0595 | .0259 | .0107 | .0015 | 0 | .1250 |
| 35 | .0122 | .0015 | .0015 | 0 | 0 | 0 | 0 | .0152 |
| 40 | .0244 | .0046 | .0320 | .0152 | .0030 | 0 | .0030 | .0823 |
| 45 | .0076 | .0015 | .0122 | 0 | .0015 | 0 | .0015 | .0244 |
| 50 | .0183 | .0076 | .0030 | .0046 | .0030 | 0 | 0 | .0366 |
| 60 | .0091 | .0015 | .0046 | .0076 | .0122 | .0015 | 0 | .0366 |
| 70 | .0015 | 0 | 0 | 0 | .0015 | 0 | 0 | .0030 |
| 80 | .0015 | 0 | .0061 | .0015 | .0030 | 0 | 0 | .0122 |
| 90 | .0015 | 0 | .0030 | .0107 | .0030 | 0 | .0030 | .0213 |
| 100-195 | .0061 | .0030 | .0122 | .0122 | .0137 | .0076 | .0030 | .0579 |
| 200-300 | 0 | 0 | .0107 | .0061 | .0137 | .0061 | 0 | .0366 |
| > 300 | 0 | 0 | 0 | .0015 | 0 | 0 | .0015 | .0030 |
| | | | | | | | | 1.0000 |

TABLE A-XVIII

Total Cross Partitions Reported by Type (All Shelter Areas)

| Type | 1 | 2 | 3 | 4 | Total |
|---|---|---|---|---|---|
| Number | 181 | 365 | 66 | 149 | 761 |
| Fraction | .2379 | .4796 | .0867 | .1958 | 1.0000 |

TABLE A-XIX

Shelter Areas with Types 1-4 Cross Partitions Reported

| PF Category | 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | Basement Shelter Areas | | | | |
| Number | 41 | 16 | 45 | 32 | 41 | 16 | 54 | 245 |
| Fraction of Total (1030) Basement Shelter Areas | .0398 | .0155 | .0437 | .0311 | .0398 | .0155 | .0524 | .2379 |
| | | | | First Story Shelter Areas | | | | |
| Number | 40 | 8 | 26 | 12 | 3 | 3 | 6 | 98 |
| Fraction of Total (262) First Story Shelter Areas | .1527 | .0305 | .0992 | .0458 | .0115 | .0115 | .0229 | .3740 |
| | | | | Upper Story Shelter Areas | | | | |
| Number | 108 | 45 | 119 | 60 | 51 | 16 | 19 | 418 |
| Fraction of Total (838) Upper Story Shelter Areas | .1289 | .0537 | .1420 | .0716 | .0609 | .0191 | .0227 | .4988 |

TABLE A-XX

Cross Partitions in Basement Shelter Areas

(Type 1)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 1 | 1 | 2 | 0 | 2 | 0 | 3 | 9 |
| 20 | 4 | 0 | 1 | 1 | 3 | 0 | 1 | 10 |
| 30 | 1 | 2 | 4 | 1 | 4 | 0 | 2 | 14 |
| 40 | 2 | 0 | 1 | 3 | 2 | 2 | 3 | 13 |
| 50 | 1 | 0 | 2 | 0 | 1 | 0 | 3 | 7 |
| 60 | 3 | 1 | 1 | 2 | 1 | 0 | 0 | 8 |
| 70 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 4 |
| 80 | 0 | 2 | 1 | 1 | 0 | 0 | 1 | 5 |
| 90 | 5 | 0 | 3 | 2 | 4 | 0 | 4 | 18 |
| | | | | | | | | 88 |
| | | | | FRACTION | | | | |
| 10 | .0114 | .0114 | .0227 | 0 | .0227 | 0 | .0341 | .1023 |
| 20 | .0455 | 0 | .0114 | .0114 | .0341 | 0 | .0114 | .1136 |
| 30 | .0114 | .0227 | .0455 | .0114 | .0455 | 0 | .0227 | .0591 |
| 40 | .0227 | 0 | .0114 | .0341 | .0227 | .0227 | .0341 | .1477 |
| 50 | .0114 | 0 | .0227 | 0 | .0114 | 0 | .0341 | .0795 |
| 60 | .0341 | .0114 | .0114 | .0227 | .0114 | 0 | 0 | .0909 |
| 70 | .0341 | 0 | 0 | 0 | 0 | 0 | .0114 | .0455 |
| 80 | 0 | .0227 | .0114 | .0114 | 0 | 0 | .0114 | .0568 |
| 90 | .0568 | 0 | .0341 | .0227 | .0455 | 0 | .0455 | .2046 |
| | | | | | | | | 1.0000 |

TABLE A-XX (Continued)

(Type 2)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 0 | 1 | 0 | 2 | 3 | 0 | 0 | 6 |
| 20 | 5 | 1 | 2 | 2 | 5 | 2 | 5 | 22 |
| 30 | 2 | 2 | 4 | 1 | 1 | 2 | 3 | 15 |
| 40 | 2 | 2 | 9 | 5 | 4 | 2 | 5 | 29 |
| 50 | 3 | 1 | 3 | 1 | 0 | 0 | 5 | 13 |
| 60 | 1 | 0 | 2 | 2 | 6 | 0 | 3 | 14 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 80 | 0 | 1 | 0 | 1 | 2 | 0 | 2 | 6 |
| 90 | 1 | 1 | 6 | 3 | 1 | 7 | 5 | 24 |
| | | | | | | | | 130 |
| | | | | FRACTION | | | | |
| 10 | 0 | .0077 | 0 | .0154 | .0231 | 0 | 0 | .0462 |
| 20 | .0385 | .0077 | .0154 | .0154 | .0385 | .0154 | .0385 | .0692 |
| 30 | .0154 | .0154 | .0308 | .0077 | .0077 | .0154 | .0231 | .1154 |
| 40 | .0154 | .0154 | .0692 | .0385 | .0308 | .0154 | .0385 | .2230 |
| 50 | .0231 | .0077 | .0231 | .0077 | 0 | 0 | .0385 | .1000 |
| 60 | .0077 | 0 | .0154 | .0154 | .0462 | 0 | .0231 | .1077 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | .0077 | .0077 |
| 80 | 0 | .0077 | 0 | .0077 | .0154 | 0 | .0154 | .0462 |
| 90 | .0077 | .0077 | .0462 | .0231 | .0077 | .0538 | .0385 | .1846 |
| | | | | | | | | 1.0000 |

TABLE A-XX (Continued)

(Type 3)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | **NUMBER** | | | | |
| 10 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 20 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| 30 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 3 |
| 40 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 50 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 2 |
| 60 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 70 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 2 |
| | | | | | | | | 13 |
| | | | | **FRACTION** | | | | |
| 10 | 0 | 0 | 0 | .0769 | 0 | 0 | 0 | .0769 |
| 20 | .0769 | 0 | .0769 | 0 | 0 | 0 | 0 | .1539 |
| 30 | 0 | .0769 | .0769 | 0 | .0769 | 0 | 0 | .2309 |
| 40 | .0769 | 0 | 0 | 0 | 0 | 0 | 0 | .0769 |
| 50 | 0 | 0 | 0 | .1538 | 0 | 0 | 0 | .1538 |
| 60 | .0769 | 0 | 0 | 0 | 0 | 0 | 0 | .0769 |
| 70 | .0769 | 0 | 0 | 0 | 0 | 0 | 0 | .0769 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | .0769 | 0 | 0 | 0 | 0 | .0769 | 0 | .1538 |
| | | | | | | | | 1.0000 |

TABLE A-XX (Continued)

(Type 4)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 |
| 30 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 2 |
| 90 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 2 |
| | | | | | | | | 14 |
| | | | | FRACTION | | | | |
| 10 | .0714 | 0 | 0 | 0 | 0 | 0 | 0 | .0714 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | .3571 | .3571 |
| 30 | 0 | 0 | .1429 | .0714 | 0 | 0 | 0 | .2143 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | .0714 | .0714 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | .0714 | 0 | 0 | .0714 | .1429 |
| 90 | .0714 | 0 | 0 | 0 | .0714 | 0 | 0 | .1429 |
| | | | | | | | | 1.0000 |

TABLE A-XXI

Cross Partitions in First Story Shelter Areas

(Type 1)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 2 |
| 20 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 4 |
| 30 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 3 |
| 40 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 2 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| 90 | 0 | 2 | 1 | 0 | 0 | 0 | 0 | 3 |
| | | | | | | | | 16 |
| | | | | FRACTION | | | | |
| 10 | .0625 | 0 | .0625 | 0 | 0 | 0 | 0 | .1250 |
| 20 | .1250 | 0 | .1250 | 0 | 0 | 0 | 0 | .2500 |
| 30 | .1250 | 0 | 0 | .0625 | 0 | 0 | 0 | .1875 |
| 40 | .0625 | 0 | 0 | .0625 | 0 | 0 | 0 | .1250 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | .0625 | 0 | 0 | 0 | 0 | .0625 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | .0625 | 0 | 0 | .0625 |
| 90 | 0 | .1250 | .0625 | 0 | 0 | 0 | 0 | .1875 |
| | | | | | | | | 1.0000 |

TABLE A-XXI (Continued)

(Type 2)

| Average psf | PE Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 1 | 0 | 3 | 0 | 0 | 1 | 0 | 5 |
| 20 | 7 | 0 | 3 | 2 | 0 | 0 | 0 | 12 |
| 30 | 7 | 0 | 1 | 1 | 0 | 0 | 0 | 9 |
| 40 | 2 | 2 | 2 | 1 | 0 | 0 | 0 | 7 |
| 50 | 2 | 0 | 0 | 4 | 0 | 0 | 0 | 6 |
| 60 | 5 | 0 | 3 | 1 | 1 | 0 | 0 | 10 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 90 | 1 | 1 | 5 | 0 | 0 | 1 | 1 | 9 |
| | | | | | | | | 59 |
| | | | | FRACTION | | | | |
| 10 | .0169 | 0 | .0508 | 0 | 0 | .0169 | 0 | .0847 |
| 20 | .1186 | 0 | .0508 | .0339 | 0 | 0 | 0 | .2035 |
| 30 | .1186 | 0 | .0169 | .0169 | 0 | 0 | 0 | .1525 |
| 40 | .0339 | .0339 | .0339 | .0169 | 0 | 0 | 0 | .1186 |
| 50 | .0339 | 0 | 0 | .0678 | 0 | 0 | 0 | .1017 |
| 60 | .0847 | 0 | .0508 | .0169 | .0169 | 0 | 0 | .1696 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | .0169 | 0 | 0 | 0 | 0 | 0 | .0169 |
| 90 | .0169 | .0169 | .0847 | 0 | 0 | .0169 | .0169 | .1525 |
| | | | | | | | | 1.0000 |

TABLE A-XXI (Continued)

(Type 3)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 3 | 0 | 2 | 1 | 0 | 0 | 2 | 8 |
| 20 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 30 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 40 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 50 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| | | | | | | | | 15 |
| | | | | FRACTION | | | | |
| 10 | .2000 | 0 | .1333 | .0667 | 0 | 0 | .1333 | .5332 |
| 20 | .0667 | 0 | 0 | 0 | 0 | 0 | 0 | .0667 |
| 30 | .2000 | 0 | 0 | 0 | 0 | 0 | 0 | .2000 |
| 40 | 0 | 0 | 0 | 0 | 0 | .0667 | 0 | .0667 |
| 50 | 0 | .0667 | 0 | 0 | 0 | 0 | 0 | .0667 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 0 | C | 0 | 0 | .0667 | .0667 |
| | | | | | | | | 1.0000 |

TABLE A-XXI (Continued)

(Type 4)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 30 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 4 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 3 |
| | | | | | | | | 8 |
| | | | | FRACTION | | | | |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20 | .1250 | 0 | 0 | 0 | 0 | 0 | 0 | .1250 |
| 30 | .1250 | .1250 | .1250 | 0 | .1250 | 0 | 0 | .5000 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | .1250 | 0 | 0 | 0 | .2500 | .3750 |
| | | | | | | | | 1.0000 |

TABLE A-XXII

Cross Partitions in Upper Story Shelter Areas

(Type 1)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 2 | 5 | 4 | 3 | 2 | 2 | 0 | 18 |
| 20 | 2 | 3 | 5 | 1 | 5 | 1 | 0 | 17 |
| 30 | 3 | 0 | 3 | 0 | 1 | 0 | 0 | 7 |
| 40 | 3 | 0 | 9 | 12 | 5 | 0 | 0 | 29 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| 90 | 1 | 0 | 2 | 0 | 1 | 0 | 0 | 4 |
| | | | | | | | | 77 |
| | | | | FRACTION | | | | |
| 10 | .0260 | .0649 | .0519 | .0390 | .0260 | .0260 | 0 | .2338 |
| 20 | .0260 | .0390 | .0649 | .0130 | .0649 | .0130 | 0 | .2208 |
| 30 | .0390 | 0 | .0390 | 0 | .0130 | 0 | 0 | .0909 |
| 40 | .0390 | 0 | .1169 | .1558 | .0649 | 0 | 0 | .3766 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | .0130 | 0 | 0 | 0 | 0 | 0 | 0 | .0130 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | .0130 | 0 | 0 | 0 | 0 | .0130 |
| 90 | .0130 | 0 | .0260 | 0 | .0130 | 0 | 0 | .0519 |
| | | | | | | | | 1.0000 |

TABLE A-XXII (Continued)

(Type 2)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 7 | 7 | 6 | 3 | 0 | 0 | 0 | 23 |
| 20 | 32 | 9 | 4 | 9 | 0 | 0 | 0 | 54 |
| 30 | 13 | 9 | 10 | 2 | 1 | 0 | 0 | 35 |
| 40 | 8 | 1 | 6 | 5 | 9 | 3 | 14 | 46 |
| 50 | 1 | 1 | 4 | 1 | 2 | 0 | 0 | 9 |
| 60 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 3 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 2 | 1 | 1 | 1 | 1 | 0 | 0 | 6 |
| | | | | | | | | 176 |
| | | | | FRACTION | | | | |
| 10 | .0398 | .0398 | .0341 | .0170 | 0 | 0 | 0 | .1307 |
| 20 | .1818 | .0511 | .0227 | .0511 | 0 | 0 | 0 | .3068 |
| 30 | .0739 | .0511 | .0568 | .0114 | .0057 | 0 | 0 | .1989 |
| 40 | .0455 | .0057 | .0341 | .0284 | .0511 | .0170 | .0795 | .2614 |
| 50 | .0057 | .0057 | .0227 | .0057 | .0114 | 0 | 0 | .0511 |
| 60 | .0057 | 0 | .0114 | 0 | 0 | 0 | 0 | .0170 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | .0114 | .0057 | .0057 | .0057 | .0057 | 0 | 0 | .0341 |
| | | | | | | | | 1.0000 |

TABLE A-XXII (Continued)

(Type 3)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 11 | 0 | 1 | 0 | 2 | 0 | 0 | 14 |
| 20 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 30 | 3 | 5 | 4 | 0 | 1 | 1 | 0 | 14 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 90 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | 38 |
| | | | | FRACTION | | | | |
| 10 | .2895 | 0 | .0263 | 0 | .0526 | 0 | 0 | .3685 |
| 20 | .1842 | 0 | 0 | 0 | 0 | 0 | 0 | .1842 |
| 30 | .0789 | .1316 | .1053 | 0 | .0263 | .0263 | 0 | .3684 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | .0263 | 0 | 0 | 0 | 0 | 0 | 0 | .0263 |
| 80 | 0 | 0 | 0 | .0263 | 0 | 0 | 0 | .0263 |
| 90 | 0 | 0 | .0263 | 0 | 0 | 0 | 0 | .0263 |
| | | | | | | | | 1.0000 |

TABLE A-XXII (Continued)

(Type 3)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 11 | 0 | 1 | 0 | 2 | 0 | 0 | 14 |
| 20 | 7 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 30 | 3 | 5 | 4 | 0 | 1 | 1 | 0 | 14 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 80 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 90 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| | | | | | | | | 38 |
| | | | | FRACTION | | | | |
| 10 | .2895 | 0 | .0263 | 0 | .0526 | 0 | 0 | .3685 |
| 20 | .1842 | 0 | 0 | 0 | 0 | 0 | 0 | .1842 |
| 30 | .0789 | .1316 | .1053 | 0 | .0263 | .0263 | 0 | .3684 |
| 40 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 70 | .0263 | 0 | 0 | 0 | 0 | 0 | 0 | .0263 |
| 80 | 0 | 0 | 0 | .0263 | 0 | 0 | 0 | .0263 |
| 90 | 0 | 0 | .0263 | 0 | 0 | 0 | 0 | .0263 |
| | | | | | | | | 1.0000 |

TABLE A-XXII (Continued)

(Type 4)

| Average psf | PF Category 2 | 3 | 4 | 5 | 6 | 7 | 8 | Total |
|---|---|---|---|---|---|---|---|---|
| | | | | NUMBER | | | | |
| 10 | 2 | 1 | 3 | 0 | 0 | 0 | 0 | 6 |
| 20 | 4 | 2 | 25 | 12 | 11 | 4 | 0 | 58 |
| 30 | 2 | 1 | 25 | 8 | 7 | 5 | 2 | 50 |
| 40 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 4 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | 2 | 1 | 0 | 0 | 0 | 3 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | 1 | 0 | 3 | 0 | 2 | 6 |
| | | | | | | | | 127 |
| | | | | FRACTION | | | | |
| 10 | .0157 | .0079 | .0236 | 0 | 0 | 0 | 0 | .0472 |
| 20 | .0315 | .0157 | .1969 | .0945 | .0866 | .0315 | 0 | .4568 |
| 30 | .0157 | .0079 | .1969 | .0630 | .0551 | .0394 | .0157 | .3937 |
| 40 | .0157 | 0 | 0 | .0079 | 0 | 0 | .0079 | .0315 |
| 50 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 60 | 0 | 0 | .0157 | .0079 | 0 | 0 | 0 | .0236 |
| 70 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 80 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 90 | 0 | 0 | .0079 | 0 | .0236 | 0 | .0157 | .0472 |
| | | | | | | | | 1.0000 |

## Appendix B

### Characteristics of Buildings Used in Area Factor Computations

PF computations were made for the six points shown in Figure 4 of Chapter 3 for the fifth story of a square, seven story, windowless building exposed to infinite planes of contamination. These computations were made using the same structural data required to give a desired PF in the center of the building. For ground contribution, using the AE Guide, a height correction factor of 0.5 was used. For roof contribution, using the Engineering Manual, the distance from the detector to the roof (Z) was 27 feet. Because of no apertures, there was no floor weight correction factor required.

The wall and overhead mass thicknesses used for given center PF's in the various sized buildings subject to combinations of roof and ground contribution were:

1. Exterior Walls

| Area (Sq. Ft.) | Center PF | Mass Thickness (psf) All R* | $\frac{3}{4}$R & $\frac{1}{4}$ G** | $\frac{1}{2}$ R & $\frac{1}{2}$ G | $\frac{1}{4}$ R & $\frac{3}{4}$ G | All G |
|---|---|---|---|---|---|---|
| 5,000 | 55 | - | 166 | 133 | 115 | 103 |
| | 85 | - | 188 | 154 | 134 | 123 |
| | 125 | - | 203 | 172 | 153 | 140 |
| 7,500 | 55 | - | 158 | 125 | 109 | 95 |
| | 85 | - | 180 | 148 | 127 | 114 |
| | 125 | - | 195 | 164 | 147 | 133 |
| 10,000 | 55 | - | 152 | 120 | 103 | 91 |
| | 85 | - | 174 | 142 | 121 | 106 |
| | 125 | - | 189 | 159 | 141 | 127 |

2. Overhead

| Area (Sq. Ft.) | Center PF | All R* | $\frac{3}{4}$R & $\frac{1}{4}$ G** | $\frac{1}{2}$ R & $\frac{1}{2}$ G | $\frac{1}{4}$ R & $\frac{3}{4}$ G | All G |
|---|---|---|---|---|---|---|
| 5,000 | 55 | 95 | 109 | 124 | 155 | - |
| | 85 | 114 | 126 | 144 | 178 | - |
| | 125 | 130 | 142 | 161 | 191 | - |
| 7,500 | 55 | 98 | 111 | 126 | 157 | - |
| | 85 | 117 | 128 | 146 | 180 | - |
| | 125 | 132 | 144 | 162 | 192 | - |
| 10,000 | 55 | 100 | 113 | 127 | 158 | - |
| | 85 | 119 | 130 | 147 | 181 | - |
| | 125 | 133 | 145 | 163 | 193 | - |

* R = Roof Contribution
** G = Ground Contribution

Unclassified
Security Classification

**DOCUMENT CONTROL DATA - R&D**

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13. ABSTRACT This constitutes the final report of the research on area factors and categorization of building structural characteristics which was completed under Contract No. OCD-PS-64-56 before management responsibilities were transferred to USNRDL.

A statistical study of NFSS Phase 2 building structural characteristics extracted from OCD files is reported. A total of 844 buildings of the original Phase 1 sample of 1541 was surveyed by AE's in the NFSS Phase 2. Included in these buildings are 1030 basement shelter areas, 262 first story shelter areas, and 838 upper story shelter areas. The modal value for basement sill heights is 5 feet; whereas 80% of the sill heights of the first stories are from 2 to 3 feet, and for upper stories 90% are from 2 to 3 feet. Parallel partitions occur in 51% of the basement shelter areas, 68% of the first story shelter areas, and 78% of the upper story shelter areas. Cross partitions occur in 761 of the 2130 shelter areas.

"Area factors" are multipliers used to estimate the fraction of the total floor area offering protection greater than a predetermined value. A unique set of area factors which do not vary with structural details of the building are used in the NFSS. Several shortcomings of these approximate area factors are discussed: cases in which center PF's are lower than off-center PF's; the effect of interior partitions, floor thickness, and apertures; and shelters with predominantly roof contribution. Analyses of shelters with only roof contribution and of shelters with both ground and roof contribution are presented. Methods of determining more nearly correct area factors for each situation are given. For more exact computations, it is recommended that the shelter area be calculated by computing PF's at several off-center locations and determining graphically the areas which reach a prescribed PF.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

| 14. KEY WORDS | LINK A ROLE | LINK A WT | LINK B ROLE | LINK B WT | LINK C ROLE | LINK C WT |
|---|---|---|---|---|---|---|
| Civil Defense Systems | 8 | 4 | | | | |
| Statistical Analysis | | | | | 8 | 4 |
| Shelters | | | | | 2 | 3 |
| Classification | 10 | 2 | | | | |
| Shielding | | | 5 | 2 | | |
| Geometry | | | 5 | 2 | | |
| Surveying | 10 | 1 | | | | |
| Data | 1 | 3 | | | | |
| Buildings | | | | | 1 | 1 |
| National Fallout Shelter Survey | 8 | 4 | | | | |
| Protection Factor | | | 10 | 4 | | |
| Fallout Shelter | | | | | 8 | 4 |
| Area Factor | | | 8 | 4 | | |
| Procedures | | | 10 | 2 | | |

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OCD Subtask 1115B - Final Report R-OU-154

Cost and Protection Analysis of NFSS Structures, E. L. Hill and Carolyn M. Parker
22 January 1965 (UNCLASSIFIED) 75 pps.

This constitutes the final report of the research on area factors and categorization of building structural characteristics which was completed under Contract No. OCD-PS-64-56 before management responsibilities were transferred to USNRDL.

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"Area factors" are multipliers used to estimate the fraction of the total floor area offering protection greater than a predetermined value. A unique set of area factors which do not vary with structural details of the building are used in the NFSS. Several shortcomings of these approximate area factors are discussed: (1) cases in which center PF's are lower than off-center PF's; (2) the effect of interior partitions; (3) the effect of floor thickness; (4) the effect of apertures; and (5) shelters with predominantly roof contribution. Analyses of shelters with only roof contribution and of shelters with both ground and roof contribution are presented. Methods of determining more nearly correct area factors for each situation are given. For more exact computations, it is recommended that the shelter area be calculated by computing PF's at several off-center locations and determining graphically the areas which reach a prescribed PF.

CIVIL DEFENSE SYSTEMS, STATISTICAL ANALYSIS, SHELTERS, CLASSIFICATION, SHIELDING, GEOMETRY, SURVEYING, DATA, BUILDINGS, NATIONAL FALLOUT SHELTER SURVEY, PROTECTION FACTOR, FALLOUT SHELTERS, AREA FACTOR, PROCEDURES.

THE RESEARCH TRIANGLE INSTITUTE, Durham, North Carolina
OCD Subtask 1115B - Final Report R-OU-154

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